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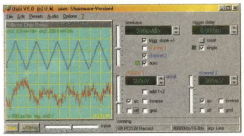

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Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc.(Hons.)

Technical Staff
John Clarke, B.E.(Elec.)
Peter Smith
Ross Tester
Jim Rowe, B.A., B.Sc, VK2ZLO
Rick Walters

Reader Services
Ann Jenkinson

Advertising Enquiries
Leo Simpson
Phone (02) 9979 5644
Fax (02) 9979 6503

Regular Contributors
Brendan Akhurst
Rodney Champness, VK3UG
Julian Edgar, Dip.T.(Sec.), B.Ed
Mike Sheriff, B.Sc, VK2YFK
Philip Watson, MIREE, VK2ZPW
Bob Young

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PUBLISHER'S LETTER

Video cassette recorders: the end is nigh

Eighteen years ago, in July 1984, writing the editorial for "Electronics Australia" magazine, I went out on a limb and stated that the VHS format had won the battle against the Beta format video machines. That editorial caused untold angst in certain sections of the electronics industry at the time. I was thoroughly lambasted, large advertising contracts were cancelled and so on. Yet as little as six months later, it *was* all over, including the shouting. VHS definitely did win the war.

Now, almost 18 years to the day, it is possible to forecast the end of domestic VCRs and this time around there is not likely to be much controversy (I hope). The signs are all there – prices for basic VCRs have dropped to less than $200, tapes are really cheap and DVD releases of movies are now very plentiful and getting cheaper by the day. For anyone who has DVD player, buying a VHS-movie is unthinkable because DVD image quality is far better.

With these trends in mind, you have to wonder how long it will be before video shops cease stocking video tapes for rental or for sale of new release movies. If you go into any video store you will soon realise that it is the DVDs that are the hot items, not video tapes. And once the video shops do cease handling video tapes for rental then it really will be all over.

What about recording video programs, you might ask? Well, VCRs are still the only way to do it cheaply and people still want to "time-shift" programs but I get the impression that it is less used than once was the case. In any event, lower priced recordable DVDs are not far away and when they eventuate you can bet that they will quickly swamp the market.

So we really are seeing a product, the VCR, coming to the end of its life cycle. All told, it has lasted, or will last, about 30 years or so, not long for a product that has involved such a high level of technology.

Mind you, if your present VCR is on its last legs, you might want to think about buying a new one. They are not going to get much cheaper and if you have a big collection of video tapes you will still want something to play them on over the next ten years or so.

Apart from that, will anyone mourn the passing of the VCR? Not really, I think. I doubt whether servicemen will care much either, particularly as they have been doing less and less service on them over the years – and they always were a mechanical nightmare anyway. And how many people ever learned to program their VCRs? Precious few!

Roll on technology!

Leo Simpson

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MAILBAG

RIAA preamplifier may need more gain

My reason for writing concerns the magnetic cartridge preamplifier design published in the March 2002 issue of SILICON CHIP. In the article, it is suggested that the output of a magnetic cartridge is typically 5-10mV at centre frequencies. However, this is really only the case for lower-quality cartridges, which tend to have poor tracking and high distortion.

High quality cartridges, such as those made by Shure and Ortofon, are more likely to have an output of 2-3mV. As I recall, even the Stanton 68x series of cartridges, which were considered to have higher-than-average output, gave a nominal 4mV.

The issue is important because an RIAA preamplifier using a single stage of IC amplification is limited to a gain of about 40dB (ie, x100) at centre frequencies. This is because almost an extra 20dB of gain is required to provide the low-frequency boost. For good quality audio reproduction, a gain after feedback of 60dB is about the limit for good-quality ICs, whether they be single (TL071, NE5534 etc) or dual (LM833, NE5532 etc). The technical reasons for this limit are well-explained in Analog Digital's application notes for one of their high-performance linear ICs (type OP27, I think).

With a cartridge delivering 2-3mV of output and a 40dB RIAA preamplifier, the output level will be 200-300mV, considerably less than the norm for modern peripherals such as CD players, tuners, VCRs and cassette decks, most of which have a nominal output of 1V or more. This discrepancy can have some uncomfortable, and even damaging, consequences if one forgets to adjust the volume control before switching from the record player to some other input.

The simplest solution to this problem is to add a buffer stage (x4 is about right) after the RIAA preamplifier. However, I seem to recall that lower overall noise can be obtained by dividing the required x400 or x500 amplification about equally between two IC stages. A modified version of the 2-stage RIAA preamplifier designed by David Tilbrook (ETI September 1981) does this job quite nicely and delivers an output level which is more consistent with modern peripherals.

I was pleased to see the use of a PC-mounted toroidal transformer (available from Altronics and specialist suppliers) in the RIAA preamplifier design. I have used these transformers in a number of my projects and have been impressed by their construction, quietness and low external field when used in sensitive audio equipment.

Brian Knight,
Evandale, SA.

Comment: you are right in that some cartridges may need an additional stage of amplification to bring them up to par. However, there is no particular benefit in splitting the gain evenly between two stages. The reason for this is that the noise performance of the whole preamplifier is largely determined by the input stage of the first op amp.

Solar panels not worthwhile in NZ

Very gratifying to see both Leo Simpson and Ross Tester, in the editorial and article in the March 2002 issue, showing a healthy dose of common sense about the usefulness of solar power at this stage of development.

Often I have cringed when I have heard some "greenies" proclaim their short-sighted vision of how much better the world would be if only we would let them have things their way. The greenies have a noble attitude but bless their well-meaning hearts, I think their reason and their logic sometimes let them down.

In NZ where I live, I am always amused when I see environmentalists buying solar panels to get "free, non-polluting" electricity. NZ's power is generated by the environment itself (how friendly can it get?) using hydro-electric and geothermal methods and these sources of energy will probably be provided freely by Mother Nature until Judgement Day!

I might have a blinkered view but I still think it's a bit loony for environmentalists in NZ especially to waste good money buying expensive, inefficient solar gear which has already harmed the environment by its manufacture.

SILICON CHIP's reportage of solar energy should be compulsory reading for all "fad" environmentalists. Keep up the good work.

Stan Hood,
Christchurch, NZ.

Are photovoltaic cells really green?

Thank you for your March feature article "Solar Power for All". Given the current environmental "Solar is Green and Green is Good" hype, it is pleasing to see that someone is willing to scrutinise the claims made by manufactures and others on the performance of photovoltaic cells.

However, there is one question I have regarding photovoltaic cells when ever their performance/efficiency is discussed. Does a photovoltaic cell produce more energy in its lifetime than it takes to manufacture it? I think this question is more fundamental in the debate of claims that photovoltaic cells are clean, green and non-polluting than cost/efficiency issues.

I suspect not, however I don't have any conclusive proof of this. My argument here is what's the point in expending energy making photovoltaic cells (and in the process producing CO_2 as nearly all Australian electricity production does) if they don't return an equivalent amount plus interest.

Don't get me wrong, I do believe

that photovoltaic cells have their place in power production (eg, remote areas where there is no power grid). However, as an "alternative" power source in urban areas the energy equation just does not stack up.

Glenn Mayall,
Gosford, NSW.

Tip on making PC boards

Further to the excellent article by Heath Young in the February 2001 issue on making PC boards by toner transfer, your readers might like to know that using a modern family iron can be less than successful for a number of reasons, including steam holes, not hot enough and not heavy enough.

I discovered that if the iron can't make the paper go brown – it is not hot enough. I bought an ancient 700W Hecla electric iron (heavy, no steam holes, no thermostat!) for $5 from a local market and it works great.

Rob Clark,
via email.

BassLink should be done properly

Wow! You certainly nailed your colours to the mast. I hope you haven't hoist your petard there by mistake.

I am referring to your editorial on the new Lucas Heights reactor in the May 2002 issue of SILICON CHIP. I want to support you and I think your "We were here first" argument has much merit. I enjoy remembering that when Tullamarine airport was being built, the Government tried to do the right thing by erecting many large signs proclaiming, "Warning! Airports are noisy neighbours!".

Controversial projects usually become controversial for good reason; they have benefits and liabilities. It isn't good science and it isn't good engineering to shut our eyes to the liabilities, and it isn't smart to ridicule people who remind us of the liabilities and who seek to minimise the harm done by those liabilities.

Before complaining of a "low level of scientific knowledge" it is useful to remember that science includes much more than physics and electricity. It is useful to remember that green and environmentalist groups are usually populated by people of above average education and that we technologists probably should welcome their input when they remind us of design criteria that we might otherwise forget.

The BassLink project is a particularly unfortunate example. The opposition to the project isn't the irrational "in there and against it" you imply. The opposition is to doing the job badly. The environmentalists want what we technologists should want – a project of which we can be proud, not ashamed.

Keith Anderson,
Kingston, Tas.

USB light not a new idea

In your March 2002 edition, your article entitled "The Itsy-Bitsy USB Lamp" is a great idea and I'm sure a lot of readers will be making one. There is one problem with the article though, and I quote from paragraph 4: "It is such a delightfully simple idea we're wondering why no-one ever thought of it before."

Actually, there is a similar commercial product that I believe I saw advertised or in shops 12 months ago. Just to check my sanity I did a quick check on **www.google.com** (key words USB and LIGHT) and came up with a number of results, the most relevant being: **http://www.kensington.com/products/pro_cas_d1334.html**

This device has a flexible shaft, it stays in the shape it's bent to, plugs into a USB port and uses a white LED to provide light, so it's not exactly the same.

Mark Grover,
Adelaide, SA.

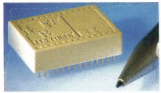
Fuel cells not necessarily clean and green

Thank you for the article on fuel cells in the May 2002 issue. It is most interesting and informative. However, I wish to correct some common misconceptions regarding these devices as power sources.

Firstly, they are not "emission free". As the diagram on the opening page of the article shows, their exhaust is water (H_2O) which is "emitted" from the cell. However, I will concede that they do not emit carbon dioxide and I suppose we should say they are "non-

continued next page

The Tiger comes to Australia



The BASIC, Tiny and Economy Tigers are sold in Australia by JED, with W98/NT software and local single board systems.

Tigers are modules running true compiled multi-tasking BASIC in a 16/32 bit core, with typically 512K bytes of FLASH (program and data) memory and 32/128/512 K bytes of RAM. The **Tiny Tiger** has four, 10 bit analog ins, lots of digital I/O, two UARTs, SPI, I^2C, 1-wire, RTC and has low cost W98/NT compile, debug and download software.

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Mailbag: continued from page 5

Greenhouse contributing" rather than "emission-free".

However, the source of their fuel, hydrogen, is possibly not "non-Greenhouse contributing." Pages 12 and 13 list a number of makers of fuel cells in the USA and show that most operate on hydrogen from an unnamed source. If this source is (for example) an electrolytic process powered by electricity from natural-gas, oil or coal-fired power stations, it may be that the use of the cells on this fuel will contribute more CO_2 to the Greenhouse effect than would the use of conventional fuels in our cars.

The DaimlerChrysler cells derive their hydrogen from sodium borohydride, which is derived from borax. My Macquarie Dictionary tells me that borax, sodium borate, is a substance "occurring naturally or prepared artificially". What is the energy consumption involved in preparing the hydrogen fuel from borax? Is the borax naturally occurring or if not, what is the energy consumption required to obtain it? What happens to the waste products from these processes?

A number of the cells are claimed to operate on ethanol as a fuel. Ethanol, C_2H_5OH, contains carbon. What happens to this carbon? The carbon in ethanol represents a little over half the energy contained. If we allow that this energy is "lost", the overall efficiency is much lower, roughly 33-40%. And how much energy is used in extracting the hydrogen from the ethanol so that the fuel-cell can use it?

UTC's petrol-powered fuel cell and Suzuki's natural-gas cell have the same problem. I am not sure how much of the total energy in petrol is contributed by the carbon; for propane, a major constituent of natural gas, it is about 50%. Again, this is apparently not utilised by the fuel-cell, nor are we told how much energy is wasted in extracting the hydrogen.

Additionally, these two petroleum-based fuels are sources of Greenhouse-contributing CO_2. Ethanol is not considered as such, since it is usually derived from growing plant matter and is part of a "local" carbon cycle. Petroleum fuels, on the other hand, are generally held to contain the carbon which was extracted from our atmosphere as it changed from CO_2-rich to O_2-rich, aeons ago. It is not considered desirable to release this carbon back into the atmosphere.

While I see fuel-cells as a desirable energy source to replace the internal combustion engine, I feel we should beware of the "hype" extolling them as the ultimate cure for our Greenhouse problems. We must realise that a lot of the information we are being given is aimed at selling the cells, rather than at fully informing the public.

Greg Mayman,
via email.

Comment: we have not yet finished the fuel-cell story. Ultimately, the hydrogen for solar cells will have to be produced directly from water by solar power if the whole process is to be really clean. And we're not talking about using solar cells for electrolysis of water – stay tuned!

Bosch ignition schematic wanted

I have a V8 VS Commodore and I need a schematic diagram for the ignition module. Bosch only gave me the pinouts of the module and this is all they can help me with. Any help would be appreciated.

Mark Sully, PO Box 274,
Niddrie, Vic 3042.
marksully@piarc.com.au
Fax (03) 9366 6872.

LP Doctor is a great project

After six months and hundreds of LPs, I can only say of your "LP Doctor" that it's one of the best projects you've ever described.

The "LP Doctor" has given a whole new life to my record collection. On some discs, the click detection LED flashes continually, yet the music sounds clean and not at all disturbed by the short interruptions as the clicks are removed. It's a great project and one that I use every day.

One thing though: what are the parameters for the treble filter? I can't detect any difference with the filter in or out! Does that mean that I have an inbuilt organic filter? Which components should I change to increase the slope of the filter?

In the May 2002 issue, you described a "32 LED Knightrider". I particularly liked the idea of a programmable stop light for vehicles. I've seen something like that before but it wasn't as versatile as your project. This was quite interesting, although I probably won't build one at the moment.

On the other hand, I can see me building a slightly different project. I envisage a multi-LED panel that spells out STOP when I hit the brakes but can also be reprogrammed to spell out BACK OFF when I am too closely approached by one of those characters who like to attach their bonnet to one's exhaust pipe! It would probably take more than 32 LEDs but I am sure there would be plenty of readers who would appreciate the chance to warn off those inconsiderate and impatient drivers one meets every day.

Jim Lawler,
Hobart. Tas.

Comment: the treble filter is very gentle, only -3dB at 10kHz and -12dB/octave above that. The reason you cannot hear any difference is that your own inbuilt filter probably cuts in well below 10kHz, perhaps as low as 5kHz or 6kHz. And it will be a "brick wall" filter rather than -12dB/octave.

Having said that, the treble filter could be made to have a much more apparent effect by increasing the 560pF capacitor at pin 6 of IC5b (& IC7b) to .001µF and the 150pF feedback capacitor to 270pF. This will drop the -3dB point to 5.6kHz.

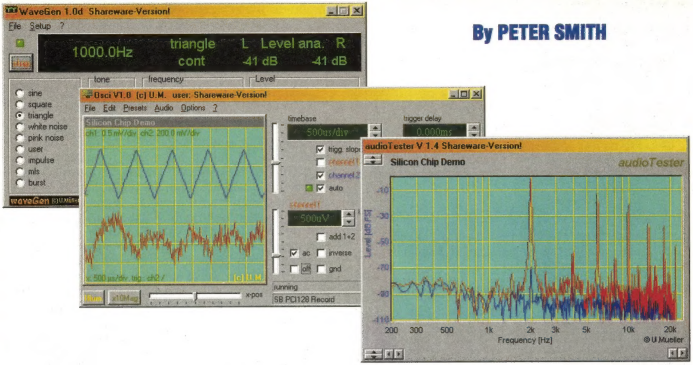
5.25-inch floppies revisited

Here's a novel recycling tip which has a mental challenge as well. 5.25-inch floppy disks still have a use – for CD storage from multi-disk CD-R spindle packs!

Cut them right along the base near the opening and remove the magnetic disk. Slide in your CD-R and it's now in its own padded storage packet.

Put the 5.25-inch floppy with the CD inside back into the paper jacket and voila, instant transport case!

Brad Sheargold,
via email.



By PETER SMITH

Digital instrumentation software for your PC

Any PC with a sound card can function as a digital oscilloscope, spectrum analyser, voltmeter and signal generator. It's just a matter of installing the right software, much of which can be downloaded for free or at low cost from the Internet.

ELSEWHERE IN THIS ISSUE, we describe a simple adapter that provides a safe and easy way of connecting test probes to your sound card. Below we introduce some of the important principles of sound card-based digital instrumentation and follow up with a quick rundown on some of the more popular software packages that are available.

Digital instrument basics

Digital instruments have many advantages over their analog cousins. Take the oscilloscope, for example. Digital 'scopes can store waveforms in memory or on disk for comparison with "live" waveforms, or play them back at a later time for detailed examination. And once a waveform is stored digitally, it is easily manipulated (level-shifted, filtered, transformed to the frequency domain, etc) for display in a variety of formats.

The downside is that digital instruments are often expensive, standalone devices with a CRT or LCD display, multiple CPUs and complex data capture electronics. However, much cheaper solutions based on the PC platform are now readily available. These utilise the existing processing power and graphics capabilities built into all PCs, thereby greatly reducing costs.

PC-based solutions range from small external data acquisition pods (we reviewed such a device in the June 2000 issue) through to add-on cards that plug into a free expansion slot. These are cheap by comparison to the standalone devices but still too costly for those of us on tight budgets.

PC sound card

The simplest and cheapest solution utilises hardware that already exists in all multimedia PCs – the sound card. It might seem unusual that a PC sound card could be used as the basis of any data acquisition system. However, one of the main components of all sound cards is an analog-to-digital (A-D) converter, a core

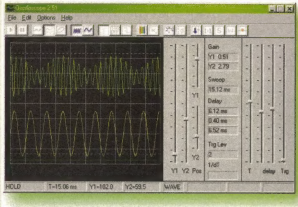


Fig.1: Oscilloscope 2.51 uses large vertical sliders for programming the sweep, gain, trigger level and delay settings for both channels.

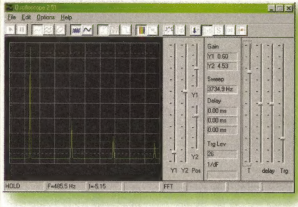


Fig.2: real-time signal spectra can be examined in FFT (Fast Fourier Transform) display mode. In this shot, Oscilloscope 2.51 plots a simple 4kHz square wave (the large spike) and its harmonics.

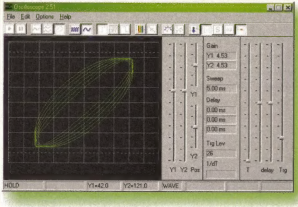


Fig.3: many 'scopes support an X-Y mode, where the amplitude of the second channel is plotted against the amplitude of the first. Here we're using Oscilloscope 2.51's delayed sweep function and X-Y mode to get a new perspective on our measurements!

function of even the most expensive digital instruments.

In simple terms, the A-D converter's job is to periodically sample the incoming analog signal and come up with a digital value that represents the instantaneous amplitude of that signal. The digital values are then processed by software to drive on-screen voltmeter displays or to plot waveforms on an oscilloscope X-Y grid.

Let's look at some of the more important aspects of the analog-to-digital conversion process in a little more detail.

Resolution

A-D converter resolution is characterised by the number of digital bits that it takes to represent the results of a conversion. Older sound cards, such as the classic SoundBlaster 2.0 and SoundBlaster Pro, have only 8-bit resolution. All recent PC sound cards have 16-bit (or higher) resolution, which equates to 2^{16} (65,536) possible discrete values.

To make some sense of this, we need to know the upper and lower limits of the voltage that can be sampled by the converter. Sound cards typically have a 0-2V input span. Applying some simple maths, we find that 2V divided by 65,536 gives 30.5µV – a respectably small slice indeed.

Bandwidth

Equally important as the signal amplitude is its frequency. Sound card converters operate at a known (programmable) sampling period under control of a crystal-locked clock. All this means is that each conversion cycle occupies a precise period, easily measured and manipulated by software to glean the signal frequency.

Naturally, the faster the input signal can be sampled, the more accurate the displayed result. Imagine, for example, a sinewave signal with a period of 100µs. If the A-D converter samples at, say, 20µs intervals, then what you would see on an oscilloscope display wouldn't look much like a sinewave. Instead, it would look like an ascending and descending "staircase".

It follows that the faster the signal is sampled, the smaller the steps will be and the less visible the staircase effect. When the sampling rate is much higher than the signal frequency, software interpolation removes virtually all traces of this "digitisation" and the waveform looks much the same as it would on a traditional analog 'scope.

Apart from affecting how waveforms appear on an oscilloscope display, the sampling frequency is important for another reason. It must always be at least twice the frequency of the signal being measured, otherwise a problem called "aliasing" occurs (see Fig.12). Most sound cards have a maximum sampling rate of 44kHz, so the highest frequency you can expect to measure accurately is 22kHz.

The minimum frequency that can be measured is about 20Hz, due to AC-coupling at the sound card inputs and a high-pass filter in the A-D block. This can be an annoying limitation when the signals you're measuring contain a DC component but a good multimeter will usually fill in the gaps.

Storage

As each A-D conversion is completed, software reads the result and stores it sequentially in a block of

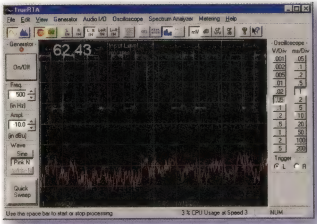


Fig.4: this view shows TrueRTA's oscilloscope and signal generator. The signal generator and righthand toolbar can be detached from the main display if required.

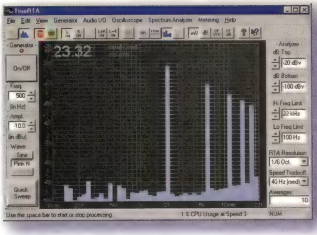


Fig.5: plot of a 2kHz square-wave on TrueRTA's spectrum analyser. This is the "level 3" version of the product, which allows up to 60 frequency bars (1/6 octave) across the horizontal axis. Display update speed can be traded off with accuracy to suit the speed of your hardware – necessary because this analyser is a real CPU hog.

memory (or "storage buffer"). As mentioned above, each cycle occupies a precise period, so the storage locations also act as time markers. Once the buffer is full, oscilloscope software can be used to read the contents and plot the traditional amplitude versus time waveforms.

Of course, this is a very simplified description of the process. Depending on the particular software and the active instrument, mathematical calculations may need to be performed on all or part of the buffer contents before the results can be displayed in the appropriate format. For example, voltmeter software might need to extract average, crest factor and RMS values from the raw data.

Triggering

The storage buffer is in effect "circular". Once full, old data is overwritten with new as the entire cycle repeats. However, although the A-D converter may be sampling and converting at full speed (called "free-running"), the software does not necessarily immediately write the results to the buffer. Rather, it monitors the incoming data for predefined trigger conditions. On most sound card-based software, the triggers are programmable to specific voltage levels – either positive (rising) or negative (falling).

Without some means of synchronising the signal with the beginning of the buffer, even simple waveforms would be impossible to comprehend on an oscilloscope; they would appear to jitter and jump across the horizontal axis. In fact, most digital instruments need reliable triggering in order to make accurate measurements.

For greater versatility, many digital 'scopes provide a variable pre-trigger (or "delay") time. This simply means that a certain number of samples are written to the buffer before the trigger condition is met.

Generating output

So far, we've only talked about instruments that utilise sound card inputs. Not surprisingly, a good deal of software is available that makes use of the outputs as well.

In operation, an analog output voltage is generated by the sound card's digital-to-analog (D-A) converter. Software feeds a stream of 16-bit digital data into the D-A block, where it's converted to analog, filtered and then amplified before appearing on the card's output sockets. As you can see, this process is similar to the signal input side, except in reverse!

Digital signal generators are the most-used output

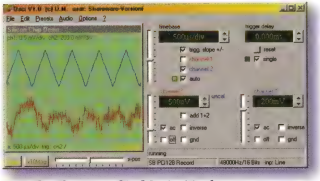


Fig.6: the "front panel" of Osci – it's almost as easy to use as rotary dials and switches!

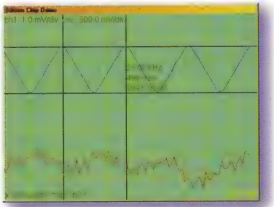


Fig.7: Osci's waveform display can be dragged away from the main window and resized as required. The dark lines on the display are measurement cursors that we used to determine the frequency and amplitude of the sinewave.

What's A Spectrum Analyser?

Most of our readers will already be familiar with the oscilloscope. These instruments display signals in the time domain. The horizontal axis is graduated in time and the vertical in amplitude. This format is ideal for determining time, phase and amplitude information.

On the other hand, spectrum analysers display signals in the frequency domain. Frequency is displayed on the horizontal scale, and is divided into bands, or octaves. The lower frequency bands are on the left, with progressively higher frequency bands to the right. The scale is logarithmic, such that each octave or fractional octave is equal in width. The amplitude of the signal is displayed on the vertical axis, which is graduated in decibels.

A spectrum analyser enables us to see certain information that is just not visible in the time domain. For example, a sinewave may look good in the time domain but show visible distortion in the frequency domain. Also, a noise signal may look totally random in the time domain but in the frequency domain one frequency may be dominantly present.

In audio frequency work, the spectrum analyser is commonly used to measure signal-to-noise ratio, distortion, intermodulation distortion and frequency response.

A mathematical process called Fast Fourier Transforms (FFTs) is used to convert signal information from the time domain to the frequency domain. To complicate matters further, analyser software often includes several complementary FFT "windowing" functions. Unfortunately, a detailed explanation of windowing, or FFTs for that matter, is well beyond the scope of this article. However, plenty of information on the subject is available on the Internet and in printed form.

instruments. Together with the instruments we mentioned earlier, they provide a convenient means of analysing a host of analog circuitry. Just like their analog counterparts, digital signal generators provide the usual sinewave and square-wave outputs with programmable frequencies and amplitudes. Some even include sweep generators and noise sources for frequency response and distortion analysis.

The software

OK, now that you're familiar with some of the basic terms, let's examine a few of the more popular digital instrument packages that are available on the Internet.

We have selected five quite different software packages that we think demonstrate the capabilities of sound card-based instrumentation quite well. These are all listed in Table 1, along with the links to their download sites. Some are free for non-commercial use, while others are offered on a shareware basis.

Many more are available – too many for us to seriously evaluate here. Our advice is to shop around and be sure to "try before you buy"! For additional software, point your browser to **www.google.com** and search for *sound card oscilloscope software*.

Oscilloscope 2.51

The first package we examined is titled simply "Oscilloscope 2.51". It runs on Windows 95 & 98 (a Windows 3.1 version is also available) and requires only an 80486 processor and an 8-bit sound card. In common with most packages, it includes a dual-trace storage 'scope, as well as a real-time spectrum analyser.

All major functions are controlled via a series of "click-and-drag" sliders on the righthand side of the display (see Fig.1). Vertical trace position, gain, and trigger level are all independently programmable for left (Y1) and right (Y2) channels.

In single trace (YT) mode, two trigger delay sliders provide coarse and fine adjustment of the amount of pre-trigger data written to the buffer. In dual trace and X-Y mode, these sliders vary the time delay between the Y1 and Y2 channels.

The gain settings control software gain only; hardware gain must be varied via the Windows audio mixer software. In addition, the product of the left and right sliders is used to determine gain when in spectrum analyser mode. This provides a convenient, faster-than-linear adjustment rate.

The sampling rate can be set to 11.025kHz, 22.05kHz or 44.1kHz. On all but the slowest (486) hardware, it makes sense to sample at the maximum supported frequency for best accuracy. The buffer (and hence display) refresh rate can be programmed to any realistic value, with the default of 330ms being too slow for smooth updates. High-performance PCs will support a much faster rate than this.

Frequency measurements are made by left and right-clicking on the oscilloscope display. Oscilloscope 2.51 measures the period between the selected points and displays the result on the status line. In Spectrum Analyser mode, it's only a matter of running the mouse over the area of interest, as the frequency of the plot at the cursor position is displayed in real time.

A snapshot of the buffer can be saved to disk as an ASCII file for use by other CAD packages. Of course, you can also cut and paste the 8 x 10 graticule display into your favourite graphics program for documentation purposes as needed.

All up, this tidy little package uses few resources but offers a lot. However, it lacks a means of calibrating the input signal levels, so all amplitude measurements should be considered relative rather than true.

TrueRTA

TrueRTA (Real Time Audio Spectrum Analyser) is a complete suite of audio test instruments. The latest release (V2.0 as we write) is available in four distinct levels. The levels differ in functionality and price, with

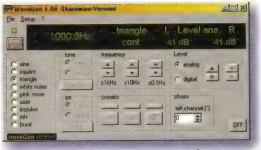


Fig.8: WaveGen can generate just about any waveform you care to name. Digital signal generators are quite frequency-accurate but distortion at the high and low ends of the scale must be considered.

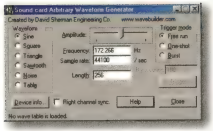


Fig.9: if you need a simple no-cost generator, check out SoundArb. You can even roll your own waveforms!

level 1 available free of charge.

TrueRTA runs on all 32-bit versions of Windows and requires a Pentium 200 (or equivalent) processor with 64MB of RAM and a 16-bit sound card as a minimum. Included in the package is a spectrum analyser, oscilloscope, digital multimeter and signal generator.

This package is aimed squarely at the audio test and development area. The built-in signal generator (with digital sweep function) and the spectrum analyser enable quick evaluation of audio circuit performance. In addition, support is provided for a calibrated microphone input, enabling loudspeaker and acoustic environment testing.

As with most packages, the input sampling rate can be set to any one of the standard sound card values between 8kHz and 48kHz.

User controls are intelligently arranged and clearly labelled (see Fig.4) and the instruments are dead easy to drive. You simply select between the oscilloscope or spectrum analyser instruments and then fine-tune the settings using buttons and drop-down menus on a detachable toolbar.

The digital 'scope provides both single (left or right channel) and dual-trace (left & right channel) modes, as well as channel addition and subtraction. The horizontal axis can be programmed from .05ms to 200ms per division, while the vertical axis ranges from a low 100μV per division right up to 5V per division. The ranges are variable in the traditional 1-2-5 steps via rows of buttons on the toolbar.

The digital voltmeter displays the RMS value of the reference channel in the top left corner of the graticule. If you decide to purchase one of the higher-level versions, you get additional voltmeter readouts of dBu, crest factor in dB (ratio of peak to RMS level) and crest factor in mV/V.

The reference channel, by the way, is the one that you select as the trigger source. Triggering is automatic – no provision has been made for varying the level or polarity.

A single click on the toolbar switches to spectrum analyser mode (see Fig.5). The graticule is now displayed in logarithmic format – the vertical axis in dB and the horizontal axis in bands of frequencies. The free version of the software provides only a single octave across the horizontal, which equates to 10 bands (or bars) in the 10Hz-22kHz spectrum. Pay money, and you can select from 1/3, 1/6, 1/12 or 1/24 octave (30, 60, 120 or 240 bar) displays.

The horizontal scale can be expanded for detailed examination of a particular frequency range by modifying the upper and lower frequency limits. Similarly, vertical scale limits can be adjusted to zoom in on an area of interest.

TrueRTA's signal generator includes both sinewave and pink noise output. The output level is variable over

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the entire range of the sound card's D-A circuitry and the sinewave frequency is variable from 5Hz to 24kHz. Higher-level versions of the product include a logarithmic sine sweep function for more accurate frequency response measurements.

Unlike the previous package, this one includes comprehensive calibration features. The professional version (level 4) even includes a feature to remove the "coloration" that sound cards inevitably add to your distortion and frequency response measurements.

As this package focuses on the real-time aspect of audio work, it does not have a number of features that are handy for general electronics bench work, such as moveable measurement cursors, triggering options and storage capabilities.

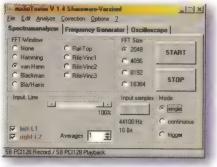


Fig.10: if you want to do serious work in the audio spectrum, AudioTester offers a comprehensive range of FFT functions.

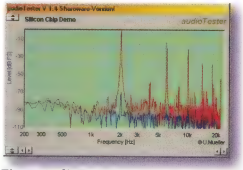


Fig.11: AudioTester's spectrum analyser is a dual-channel affair, allowing direct comparison between reference and test signals.

Osci

This is one of the best of the low-cost digital 'scopes that we've seen. Although the shareware version is not crippled in any way, it does have a maximum use period of 15 minutes. Once this expires, the program terminates and you need to relaunch it. Of course, if you like the product, you can license it for a nominal fee and get rid of this annoyance.

Osci runs on Windows 95, 98 and NT4 and requires at least a Pentium 266 with 32MB of RAM and a 16-bit sound card. If you want to run a signal generator in parallel with the 'scope, your sound card and its driver software must support "full-duplex" mode. This applies to all packages, by the way, not just Osci.

All sound card sample rates up to 96kHz are accommodated, as is 24-bit resolution for those cards that support it. In addition, Osci supports up to three sound cards, so you don't need to dismantle your existing audio setup.

The Osci user interface is uncomplicated and easy to drive (see Fig.6). Vertical (Y) axis settings are variable from 100µV per division up to 2V per division, while horizontal (X) axis (or "timebase") settings are variable from 20µs to 200ms per division in the usual 1-2-5 steps.

Trigger levels are independently programmable for channel 1 (left) and channel 2 (right) via vertical sliders and can be of either positive or negative polarity. Auto triggering is also provided, as is variable trigger delay and a single sweep mode.

Left and right channels can be added, subtracted and/or inverted. The inversion function could be handy if you have a sound card that inverts input signals (don't laugh, we've heard of some that do!).

Waveforms are displayed on a standard 8 x 10 graticule that can be detached from the main window and resized to suit your needs (see Fig.7). Optionally, the X and Y-axis settings can be displayed right on the graticule – a very handy feature for documentation purposes.

Osci's display can be printed on demand or copied to the Windows clipboard for pasting into your favourite application. In addition, the buffer contents can be saved as an ASCII file for use in other programs.

The storage buffer generally holds more than can be displayed on-screen at one time, so a horizontal scroll bar at the bottom of the display allows quick panning from buffer beginning to end. A nearby "x10 Mag" button allows you to instantly zoom into areas of interest.

Getting accurate waveform measurements is easy with this package. Click on the start point with your left mouse button, drag the horizontal and vertical rulers that appear to the end point and release, and hey-presto – the period, frequency and amplitude of the bounded area appear as if by magic!

Finally, all your settings can be saved as "presets" for quick restoration later.

Table 1: PC Instrumentation Software

Package	Licence	Download Link
Oscilloscope 2.51	Freeware	polly.phys.msu.su/~zeld/oscill.html
True RTA	Level 1 is free, Levels 2-4 are activated on purchase	www.trueaudio.com
Osci, WaveGen, AudioTester	Shareware (30-day evaluation)	www.sumuller.de/audiotester
SoundArb	Freeware	www.wavebuilder.com
Analyzer 2000	Shareware (30-day evaluation)	www.brownbear.de
Digital Sound Generator	Freeware	heliso.tripod.com/download/download.htm

WaveGen

WaveGen is a comprehensive standalone signal generator. Tone, impulse and sweep generators are all included and accessible from the front panel. WaveGen can be used in conjunction with Osci (they're from the same author), so system requirements are the same for both packages.

The maximum D-A conversion rate of the sound card determines the highest output frequency. For a

typical 48kHz card, the highest frequency will be 24kHz. The minimum frequency is listed as 0.1Hz but this seems a bit optimistic as it dips well under the lower frequency limit of around 20Hz for most sound cards. Generator frequency can be programmed in 0.1Hz, 10Hz and 1kHz increments.

As you can see from Fig.8, all the usual waveform types can be generated. In addition, WaveGen will play back any user-defined WAV file.

Output levels can be adjusted with either "analog" or "digital" control buttons. As far as we could determine from the documentation, the 0dB to -96dB digital level adjustment is software-based, whereas the 0dB to -48dB analog adjustment controls the Windows mixer.

No calibration is provided for the line output socket. Instead, when using WaveGen for frequency response and distortion measurements, the documentation suggests that you feed the right line output directly back to the left line input, so creating a "reference" channel.

The right output also connects to the input of the circuit under test, while the output of the circuit under test is connected back to right line input. This method allows you to compare the differences in the two waveforms on an oscilloscope or spectrum analyser display. The spectrum analyser instrument in AudioTester (which we mention below) expects this connection and can automatically compensate for sound card amplitude and frequency response characteristics.

Virtually all generator parameters can be configured via setup buttons on the front panel. We won't bore you with all the details here. Instead, why not download WaveGen and check them out for yourself!

SoundArb

This is a no-frills, easy-to-drive signal generator. It runs on Windows 95 and above, requires a 16-bit sound card and only minimal PC hardware – and it's free!

A shot of SoundArb's super-simple front panel is shown in Fig.9. Sine, square, triangle, sawtooth and white noise waveforms can all be generated, as can user-defined arbitrary waveforms. These are loaded from a simple ASCII file, which can be manually created or generated by software.

Normally, SoundArb outputs the selected waveform on both the left and right channels. Optionally, a synchronisation signal can be output on the right channel

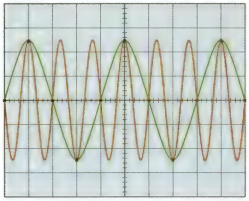


Fig.12: the A-D converter must sample the input signal at least twice as fast as its frequency otherwise "aliasing" results. Here, the input signal (shown in red) would need to be sampled at least twice each period but instead it's sampled only once every 2/3 period. Therefore, the frequency of the signal is erroneously calculated to be much lower than it really is (as shown in green).

instead by choosing the "Right channel sync" option. The output amplitude is set by a horizontal slider and is uncalibrated.

SoundArb provides simple triggering options and these include "Free run", "One-shot" and "Burst". The burst mode length is programmable in cycles.

AudioTester

AudioTester boasts just about every feature imaginable. Like TrueRTA, it includes an oscilloscope, spectrum analyser and signal generator but lacks a separate voltmeter.

We've mentioned this package only because it originates from the same author as Osci and WaveGen. These two standalone instruments are apparently intended to replace the oscilloscope and signal generator that are part of the AudioTester suite. To date, the author has not released a standalone version of the spectrum analyser, so AudioTester is still available to fill in the gaps.

Like Osci and WaveGen, the spectrum analyser in AudioTester is packed with features. We've run out of space to describe them here but we've included a couple of screen shots (Figs.11 & 12) to whet your appetite!

SC

These days more and more electronic equipment uses tiny tantalum capacitors, with capacitance values that were impossible in such small volumes only a few years ago. This is the story of how they are made.

The how, when, where and why of a Tantalum Capacitor

By PETER HOLTHAM

Just as silicon chips pack more and more function into less and less space, other electronic components have also shrunk. Tiny surface mount resistors replace the wire-ended components of just a few years ago.

Capacitors used to be bulky items – even the low voltage types. But like resistors, they too have shrunk to minuscule proportions.

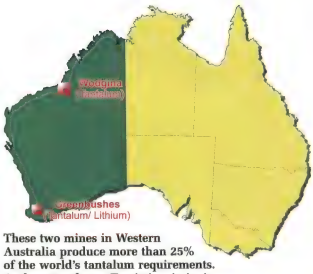
Few people realise that the key to making some of these very tiny capacitors is found deep underground in Western Australia. It is the rare mineral tantalite, a complex oxide of iron, manganese and tantalum, and the principal source of tantalum metal.

Two mines in the state supply more than a quarter of the world's annual tantalum requirements. One is outside the small town of Greenbushes, 250km south of Perth. The other is at Wodgina in the remote Pilbara region, 1500km north of Perth.

Australian gold mining company Sons of Gwalia owns both and together they form the world's largest known tantalum resource. Fifty eight million kilograms of tantalum (as tantalum pentoxide) has been found, enough to give both mines at least 25 years more life.

The tantalum bearing ore is mined from huge open pits by drilling and blasting. Every tonne mined requires the removal of nearly seven tonnes of waste rock.

The ore trucked out of the pit contains just over 200 grams of tantalite mineral per tonne (or 200 parts per million), far too little to be saleable. So the trucks dump their loads at processing plants close to the mines.



These two mines in Western Australia produce more than 25% of the world's tantalum requirements. And yes, we know Tassie is missing!

Here, crushers followed by grinding mills pulverise the ore to a powder. This allows the few specks of denser tantalite to be separated from the great bulk of lower density waste minerals.

A final clean-up using electrostatic separators and high intensity magnets produces a saleable concentrate containing up to 40% tantalum pentoxide.

Last year these two West Australian mines produced just 500 tonnes of tantalite from 2.4 million tonnes of ore. Sons of Gwalia sells all its tantalite to two customers, Cabot Corporation in the USA and the German company, H.C Starck.

These companies extract tantalum metal from tantalite by chemical means rather than smelting. The tantalite is dissolved in hydrofluoric and sulphuric acid and then extracted into a solvent leaving impurities behind in the acid solution.

Tantalum is stripped from the sol-

It starts deep underground as the rare mineral tantalite, a complex oxide of iron, manganese and tantalum. There are just 200g of tantalite in every tonne of ore mined! This is the Wodgina open-cut mine in the Pilbara, N-W Western Australia.

The tantalum processing plant at Greenbushes, in southern West Australia. This plant also produces lithium.

vent in the form of tantalum fluoride. Finally, sodium reduction of the fluoride produces powdered tantalum metal.

More than half the tantalum goes into the manufacture of capacitors, twenty-five billion of them in 2000, up from 13 billion in 1995.

So why is tantalum used? What's so special about it that allows a tantalum capacitor to pack so many microfarads into such a small volume? A look at what a capacitor is and how it works provides the answer.

A capacitor is basically two conductors separated by an insulator or dielectric. In an air-spaced capacitor, the conductors are metal plates and the dielectric is air. The value of a capacitor, C, depends on the area A of the plates, the dielectric constant K of the insulation between them, and its thickness d. Here is the equation:

$$C = E_0K(A/d)$$

E_0 is the dielectric constant of free space; it has a value of 8.85×10^{-12} farads per metre.

The key to using this equation correctly is to get the units right. K is a ratio and has no units, area A must be in square metres and dielectric thickness d is in metres. The capacitance is then in farads.

The equation can be turned around to find the area of the plates for a particular value capacitor. For example, if you tried to make a 1µF capacitor with two plates separated by one mm of air (K for air is one), the plate area would be nearly 113 square metres. Which is why you don't find air-spaced 1µF capacitors!

It is clear from the equation there are two things you can do to decrease the plate area: increase the dielectric constant (K) or decrease the plate spacing (d).

Some capacitors use mica, another mineral, as the dielectric material between the plates. Mica has a dielectric constant of seven (Table 1). So a 1µF capacitor with one millimetre thickness of mica dielectric will be seven times smaller than the air spaced version. In fact, mica occurs naturally in very thin sheets. So the plate spacing (d) could be much less than one millimetre, making the capacitor even smaller.

In tantalum capacitors the dielectric is tantalum pentoxide, Ta_2O_5, which has a K of 26. Despite the relatively modest K compared with the very large values of some ceramics, capacitor manufacturers use tantalum for a number of reasons.

Firstly, and most importantly, it is a 'valve' metal (another is aluminium), meaning it forms a uniform stable oxide on its surface. It is easy to make tantalum pentoxide layers less than 15µm (one millionth of a metre) thick. It is this thinness of the dielectric layer that more than compensates for the comparatively low value of K.

At the same time, the layer has a high dielectric strength, meaning it is able to withstand the large electric fields that occur in the capacitor.

Secondly, tantalum can be made extremely pure. It melts at 2996°C and any impurities present evaporate off at much lower temperatures. High purity of the metal substrate guarantees high quality oxide films.

Finally, tantalum is easy to work. It can be produced as a powder, rolled into sheets and drawn into wires. It is almost immune to corrosion by acids and is stable with respect to temperature.

Temperature stability translates into excellent temperature performance in the finished capacitors. They are capable of working from -55 to +125°C

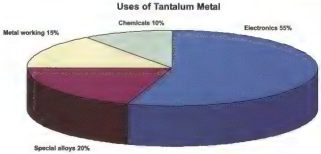


Fig.1 (left): uses of tantalum metal. Electronics, particularly tantalum capacitors, takes the lion's share of worldwide tanatalum production.

Material	Dielectric Constant K
Air or vacuum	1
Paper	2 - 6
Plastic	2 - 6
Glass	5 - 8
Mica	7
Aluminium oxide	8
Tantalum pentoxide	26
Ceramic	Variable 12-30,000

Table 1: the dielectric of many common (and some less common) materials. While not up there with most ceramics it is significantly higher than many other materials traditionally used for capacitor production.

High power microscope pics of two types of tantalum powder: nodular (left) and flake (right).

with little variation in electrical properties.

Capacitor manufacture starts with powdered tantalum metal. The typical particle size for a high voltage capacitor is 10µm. Because the dielectric layer eats into the particle, the thicker layers needed for a high voltage capacitor might consume the entire particle if it were any smaller.

As the equation above shows, capacitance is proportional to surface area. In the past 10 years, tantalum powder manufacturers have been able to change the shape of the particles from simple spheres through flakes to complex coral structures.

Each change in shape has increased the capacitance-voltage product (CV) of the powder. CV is a measure of the volumetric efficiency of a capacitor, or the number of microfarads (µF) in a given volume. Values have increased from 8000µFV/gram for simple particles to 27,000µFV/gram for coral structured particles.

What this means is simply that tantalum capacitors have steadily become smaller. Surface-mount tantalum capacitors are now available in the 0402 format; that's 0.04 by 0.02 inches, or 1mm by 0.5mm.

The powder is mixed with a binder and compressed under high pressure around a tantalum wire to make a small 'slug'. The wire will eventually become the anode of the capacitor.

Heating the slug of powder and binder under vacuum at high temperature (1500-2000°C) fuses the individual particles together. They form a strong porous sponge, with a huge internal surface area.

Connecting the slug to a positive voltage and dipping it into an acid bath allows a small current to pass through it (see Fig.2). This electrolytic process creates the dielectric layer of tantalum pentoxide on all the exposed tantalum surfaces of the sponge.

The applied voltage sets the thickness of the layer. The higher the voltage, the thicker the oxide layer. As you can see from the first equation, a thicker layer gives a lower value of capacitance. But it also means a higher voltage rating for the finished capacitor.

Typically, the layer is around 0.25µm thick. What does this mean for a typical 25µF 25VW tantalum bead capacitor two or three millimetres in size?

Putting the values for C, K and d into the second equation shows that the surface area inside the capacitor is around 209cm^2. That's about one third the area of this page.

Now look at the dielectric strength of the layer and the electric field it has to withstand in operation. The dielectric strength is simply the working voltage (25) divided by the layer thickness (0.25m), in this case an amazing 125kV per millimetre.

So far we have half the capacitor – one electrode of tantalum metal sponge and the dielectric of tantalum pentoxide. Now the second electrode is added. The slug is dipped into manganese nitrate solution which fills up all the pores in the sponge.

Heating the slug drives off the water and decomposes the nitrate to manganese dioxide, which now becomes the second electrode (Fig.3). The manganese dioxide cathode layer provides the capacitor with a unique 'self-healing' mechanism. If there is a localised imperfection in the dielectric, a heavy current will flow in this region. Resistance of the manganese dioxide causes it to heat up and change to a more resistive form, plugging the imperfection.

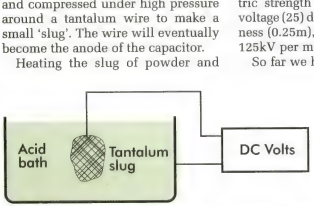
Once the manganese dioxide layer is in place, a cathode wire is glued on using a combination of graphite and silver loaded epoxy. Welding a wire to the stub of tantalum wire in the slug creates the anode lead. Fig.3 shows the layers of the finished capacitor.

All that remains to be done is to decide on the packaging method. Tantalum capacitors come as either surface mount-chips or wire-ended beads, with chips outnumbering beads by four to one in recent years.

The body is coded with its capacitance value and voltage rating, and then if it tests OK, the capacitor is ready to leave the factory.

So next time you casually reach for a tiny surface-mount tantalum capacitor, spare a thought about how it was made and where the raw material came from. It may well have started life deep underground in Western Australia. **SC**

Acknowledgement: Our thanks to Suzanna Hughes and Kevin O'Keefe, Sons of Gwalia Ltd, and John Gill, AVX Ltd Tantalum Division, for their assistance with this feature.



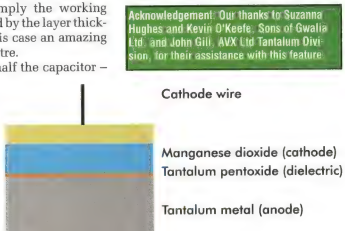


Fig.2 (above): the making of a tantalum capacitor. An electrolytic process deposits a very fine layer of tantalum pentoxide – the dielectric, on a tantalum metal slug. The coated slug is then dipped in manganese nitrate and heated, which creates the cathode of manganese dioxide. The finished capacitor is shown in graphical form in Fig.3 (right).

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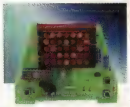

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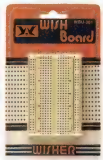

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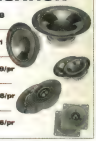

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DIGITAL STORAGE LOGIC PROBE

for Windows 98

Design by Trent Jackson
Words by Trent Jackson and Ross Tester

Here's another reason not to throw out that old computer. This fully functional Digital Storage Logic Probe is driven by a Windows-based PC. With it you can view and record valid TTL and CMOS logic levels via 32-bit Windows software. And we even supply the software!

If you have ever needed to design, service or troubleshoot digital equipment, you'll know just how valuable a logic probe can be.

Well, this one goes one step further: connect it to your PC's parallel port running Win98 and you can not only view logic states, you can record them, save them for more analysis or comparison, print them and more.

You can also locate and store high or low-going pulses via software latching and even disable unwanted logic highs or lows (via software). Unlike most conventional DSOs (Digital Storage Oscilloscopes) and similar devices, this device records true bit values – 0s and 1s – not waveforms or voltages.

You can switch between TTL and CMOS circuitry. In TTL circuits, which always operate from a 5V supply, any voltage less than 0.8V is considered to be a logic "low" and any voltage greater than 2.0V is considered to be a logic "high". Intermediate voltages are not valid.

In CMOS circuits, which can operate anywhere between about 3V and 15V, it's not quite so simple. Any voltage less than 26% of the supply voltage (Vcc) is considered logic low, while any voltage higher than 73% of Vcc is considered logic high.

How does the logic probe know what the Vcc is? Simple – it takes its power from the circuit under test!

The vast majority of CMOS circuits operate with levels between 5V and 15V (3-5V operation is rare) so for simplicity, the Logic Probe has been designed to work with 5-15V levels.

Virtually any PC which can handle Windows 98 can be used, though a Pentium-class is recommended. The parallel port is used, optically isolated from the logic probe to prevent damage to the port (and possibly the PC) should a worst-case scenario occur.

We all know that Murphy's law says that any scenario which does occur will be worst-case!

How it works

Starting at the probe, we can see a 4.7kΩ isolating resistor and then a pair of signal diodes and a zener diode. The signal diodes will clip any negative or positive-going spike which may be present when measuring, while the zener will clamp any high voltage to a safe level.

The .01µF capacitor provides not only high frequency roll-off but also gives a small amount of hysteresis to the circuit. It will also tend to integrate square wave inputs to some degree and while this is undesirable, experience has shown that the overall performance of the probe is largely unaffected.

The probe is held at a nominal 39% V_{CC} by the 560kΩ/360kΩ voltage divider across the supply. This keeps the unconnected probe in "no man's land", ie, indeterminate logic state, to avoid false conclusions when reading.

The probe is connected to the inverting input of one of IC1's two comparators and to the non-inverting input of the other.

IC1 is an LM393, a dual precision comparator. The two elements are connected to form a standard window comparator, one gate (IC1a) detecting valid high logic voltages (above its reference voltage) and IC1b detecting valid low logic voltages (below its reference voltage).

The reference voltages are provided by two voltage dividers across the supply rail. These connect to IC1's other inputs. The reference voltages vary depending on the setting of the TTL/CMOS switch. In TTL position (which assumes a 5V supply), the divider selected ensures that 2.0V is applied to one comparator and 0.8V to the other, thus giving us the required TTL logic state conditions.

In the CMOS position (which can have a wide Vcc range), the other divider puts 73% Vcc on one comparator and 26% on the other – thus achieving the CMOS logic state conditions.

The open-collector outputs of both the comparators are connected to optocouplers OPTO 1 & 2, the outputs of which in turn connect to printer port pins 10 and 11.

A third optocoupler (OPTO3) connects to pin 12 – its purpose is solely to let the software know that there is V_{CC} present. All three optos have 10Ω suppressor resistors between them and the printer port. They are low in value due to the fact that the parallel port has its own pull-up resistors.

While higher values would be desirable, they cannot work in this case because there would be too much voltage drop across them – and they could also slow the operation of the port.

The six diodes connected to the

Features:

- Full optical isolation from parallel port
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- Probe over-voltage protection
- V_{CC} reverse-polarity protection
- Low cost and very easy to build
- 32-bit Windows 98 based
- View and record logic levels
- Save and open recorded data
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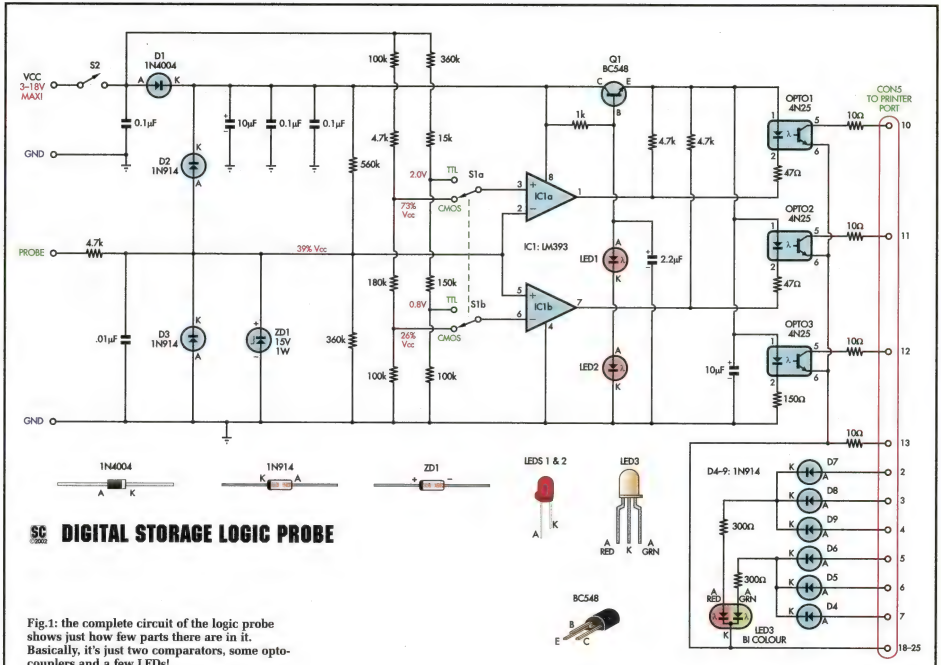
Looking at the rear of the case, showing the 26-way IDE cable which connects to your PC's parallel port. You will probably have to make this cable yourself.



DIGITAL STORAGE LOGIC PROBE

Fig.1: the complete circuit of the logic probe shows just how few parts there are in it. Basically, it's just two comparators, some opto-couplers and a few LEDs!

data lines of the parallel port (pins 2-7) form two "OR" gates (D4-D6 form one, D7-D9 form the other).

These two gates have their outputs connected, via current limiting resistors, to the anodes of a bicolour LED (LED3). This method has been used to obtain reasonable brightness from the LED by effectively paralleling the currents from the data lines.

The LED shows the high (red) or low (green) logic levels. However, it can also show whether the probe is floating (flashing green) or no V_{CC} (flashing red).

We haven't yet mentioned Q1, the 1kΩ resistor and LEDs 1 and 2. They form a 2.5V regulated supply for the three optocouplers. This is essential due to the fact that the supply voltage can be anywhere from 3–18V.

The LEDs are not used for their light emission (in fact, they're sealed inside the box!). Rather, they are used for the fact that when forward biased, each will have a constant voltage across them (about 1.5V).

Therefore Q1's base is held at a constant nominal 3V. With about half a volt or so drop across Q1's base/emitter junction, the emitter voltage remains at a constant 2.5V, give or take.

And speaking of supply, as we mentioned before this is taken from the circuit under test (by means of cables with mini crocodile or IC clips). The CMOS V_{CC} can be anywhere from 3-18V. D1 isolates the supply and provides reverse-polarity protection; the 10µF and 0.1µF capacitors provide some smoothing and bypassing.

Everything mounts on the one PC board except the banana sockets, bicolour LED and the two switches. Construction is quite straightforward.

Connecting cables

The connection between the probe hardware and computer is via a standard 26-way flat ribbon cable.

One end of this cable is fitted with a keyed 26-way IDE female plug (which mates with a 26-way male socket mounted on the PC board); the other end is fitted with a standard

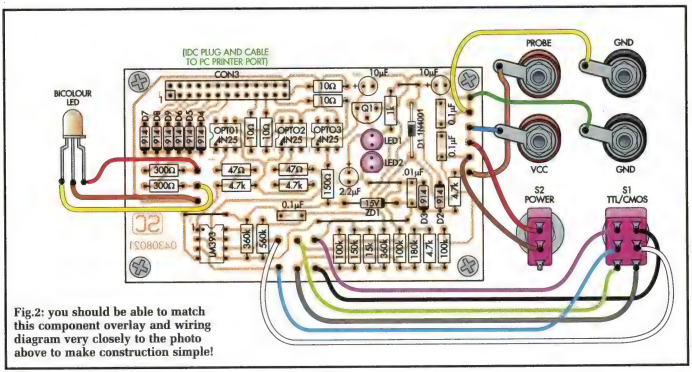
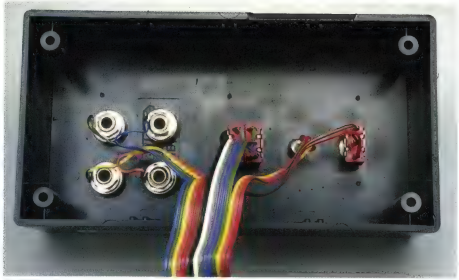
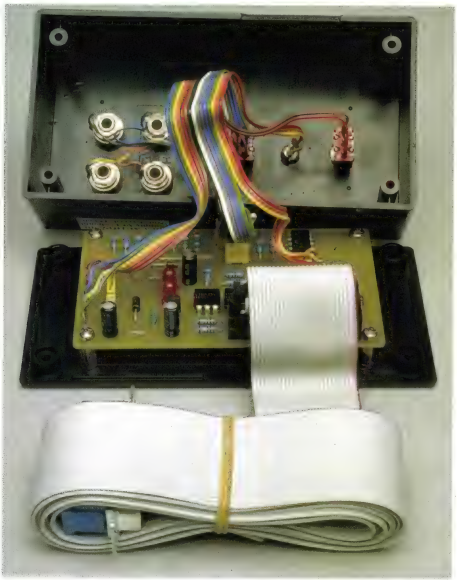


Fig.2: you should be able to match this component overlay and wiring diagram very closely to the photo above to make construction simple!



A close-up of the inside of the box to help you with the 15-way rainbow cable wiring. Use the same colour cable as we did and make life easy on yourself!



And here's the fully-opened-out project, completed and ready to close up. Notice the thin cut-out in the case (top right) for the IDE cable to pass through.

parallel port (Centronics-type) IDE plug.

It is most unlikely that this cable will be an off-the-shelf item so you are going to have to make it up yourself. It is relatively easy to do – while a special tool is normally used to fit IDE plugs to cables, it can be done in a bench vise.

IDE plugs are not soldered – tiny, sharp "fingers" pierce each wire in the cable and make connection. A clip holds the whole thing together when assembled.

Have a look at our close-up photo of the cable and you'll see that at both ends, the cable loops through the plug and then turns back on itself. The loop takes the strain off the connection itself.

You may also see a tiny arrow moulded into the PC board-end plug. This shows pin 1 and is usually the pin which the red stripe on the cable connects to.

In our case, though, the red stripe goes to the opposite end. At the parallel port plug, when you hold the plug with pins towards you so that you are looking at a letter "D", the red stripe goes to the bottom.

The other cables you will need include a set of power cables and probe cables. A collection of these is shown in the main photograph and at the end of this article – all are fitted with banana plugs at one end to go into matching sockets on the probe case. The other ends can be multimeter-type probes, small crocodile clips, IC connecting clips, and so on. The choices depend on the way you want to use the probe.

Construction

The project is mounted in a medium sized (130 x 67 x 40mm) jiffy/zippy box and, with the exception of the switches, bicolour LED and four input sockets, all components mount on a single-sided PC board measuring 95 x 57mm and coded 04308021.

We printed this little label to go on the case to show what the cable went to...

Before you start PC board construction, use it (or a photocopy of the PC board artwork in Fig. 4) as a template to drill four mounting holes in the lid of the case. Locate the board centrally and drill four 3mm holes in line with the four holes at the corners of the PC board.

After checking the board for defects, start construction by soldering in the resistors, 15 PC stakes and four wire links. You might have to scrounge a 30mm length of tinned copper wire for the longest link because it will probably be too long for the usual source of link wire, cut-off resistor pigtails.

Next, solder in the capacitors, diodes, on-board LEDs and the transistor (remember almost all those components are polarised). Likewise, all the ICs are polarised so you not only have to get them in the right spots, you have to get them the right way around!

The last "component" to go on the PC board is the 26-pin parallel port cable connector. You will note that one side of this connector has a notch cut in it. This notch goes to the outside of the PC board.

Leaving the board for a moment, it is now time to drill the case for the terminals, LED and switches. Photocopy the drilling diagram and temporarily sticky-tape it to the bottom of the case (the bottom of the case actually becomes the top!). Use this as a template to drill the holes (take note of the various sizes).

And while you're about it, you need to file a very narrow (about 1-1.5mm deep) slot in one edge of the case to allow the parallel port cable to pass through without being guillotined when you screw the case and lid together.

Parts List – Digital Storage Logic Probe

1 PC board coded 04308021, 95 x 57mm
1 plastic utility case, 130 x 67 x 44mm
1 front panel label, 124 x 63mm
1 DPDT toggle switch (S1)
1 SPDT toggle switch (S2)
4 insulated banana sockets (2 red, 2 black)
1 26-way PC-mounting IDC header socket (male)
1 26-way IDC plug (female)
1 25-way D25 male IDC plug
1 150mm length 15-way rainbow ribbon cable
15 PC stakes
4 10mm M3 tapped spacers
8 5mm M3 screws
4 rubber feet

Semiconductors
1 LM393 dual comparator (IC1)
3 4N25 optocouplers (OPTO 1,2,3)
1 BC548 or similar NPN transistor
1 15V, 1W zener diode (ZD1)
2 red LEDs, 5mm (LED1, LED2)
1 tricolour LED, 5mm (LED3)
1 1N4004 silicon power diode (D1)
8 1N914 silicon small signal diodes (D2 - D9)

Capacitors
2 10µF 25VW PC mounting electrolytic
1 2.2µF 16VW PC mounting electrolytic
3 0.1µF 50VW MKT polyester (code 104 or 100n)
1 .01µF 50VW MKT polyester (code 103 or 10n)

Resistors (1%, 0.25W) 4-band 5-band

1 560kΩ
2 360kΩ
1 180kΩ
1 150kΩ
3 100kΩ
1 15kΩ
4 4.7kΩ
1 1kΩ
2 300Ω
1 150Ω
2 47Ω
4 10Ω

OR

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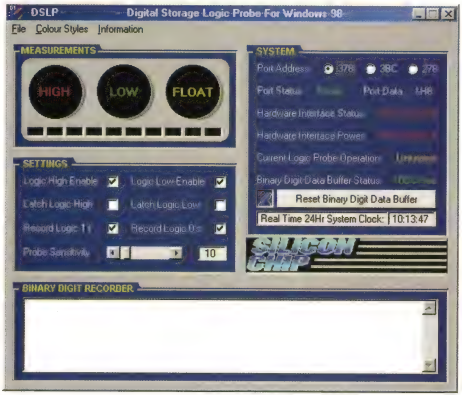


Fig.3: this is the window which should greet you when you run the DSLP.EXE file. The various panes are quite self-explanatory.

This slot needs to be just wide enough to accommodate the cable (about 34mm) and ours was about 25mm from the end of the case.

Before you mount the LED and input sockets through the bottom of the case, the front panel needs to be fitted. It can be either glued on or stuck on with (thin!) double-sided adhesive tape. Take care not to mark the panel from here on.

Use the diagrams and photos to locate the various bits. When all (including the bicolour LED) are in place, you can connect the PC board to the case with a length of 15-way rainbow cable (it's a lot easier to follow using rainbow cable than ordinary IDE cable!).

If you use the same colours as we did, you can use the photos and drawings to ensure the right wire goes to the right PC stake.

When soldering to the bicolour LED, take careful note as to which leads are which: the cathode (K) is the centre lead while the green anode is closest to the tab on the side of the LED. Therefore, the red anode is closest to the flat side.

All three leads should be shortened considerably to avoid the chance of shorting – ours were cut to about three or four millimetres long.

Now it's time for final assembly. First of all, mount the PC board on the lid using 10mm tapped standoffs. If you want to save a couple of bob, you could just use some screws through the lid with a nut both sides of the PC board.

Plug the parallel port connector cable into its socket on the PC board (remember that keyway) and place the lid/PC board assembly down into the box so the parallel port cable lies in the slot you filed in the edge of the case.

Screw the case and lid together and fix four rubber feet to the lid so the protruding PC board-mounting screwheads don't scratch any surface you sit the unit on.

And that's it! All we have to do now is look at the software and the operation of your probe.

The software

The software, DSLP.exe, operates under Windows 98 and has the standard "look and feel" of your other Windows programs.

When you open DSLP, you'll find a window with a number of panes. Top left is a measurement box which indicates standard logic conditions at a glance, with a time-delayed bar graph immediately underneath.

Next down is a settings box which enables you to toggle common settings on and off – it is used to enable and disable various parameters such as logic high and low, whether the pulses latch and so on. The probe sensitivity slider sets the sampling rate and hysteresis levels.

On the right top side of the window is the system box – the heart and soul of the software. This pane enables you to set the parallel port address (three most common ports shown) and also gives you the status of the port, whether hardware is connected or not and whether or not power is connected. Clicking on the reset binary digit data buffer box will clear all current data in the recorder box.

For good measure, there is a real-time 24-hour system clock readout.

Finally, across the bottom of the window is a binary data recorder, where incoming data is recorded in a true bit fashion.

All of these settings and controls

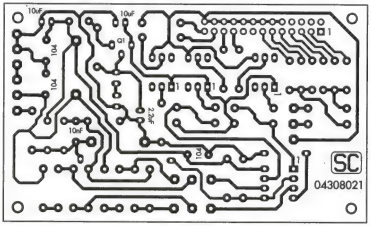


Fig.4: full size artwork for the PC board. Even if you don't make your own board, a photocopy is always handy as a drilling template.

will become self-explanatory as you use the probe.

Interfacing the hardware and software

This is extremely straightforward. As long as you are using a Pentium-based PC (or equivalent) and running Windows 98 (and of course your hardware is assembled correctly and you have loaded the software on your computer!), you should not have any problems.

Plug 'er in and away she goes...

The software, dslp.zip, can be downloaded from ***www.siliconchip.com.au***. It is a 2MB file so be patient!

Once downloaded and unzipped, run "setup" and it will install automatically.

When you run the unzipped dslp.exe file, you should be greeted with a window as shown in Fig.3. From there, it's just a matter of selecting your parameters and using the probe.

Operation

The software basically works like this: assuming a valid high level voltage is detected by the probe (and therefore present on pins 2 and 5 of IC1,) pin 1 of IC1a will go low, forward biasing OPTO1's LED and causing its transistor to conduct. This pulls pin 10 on the parallel port low.

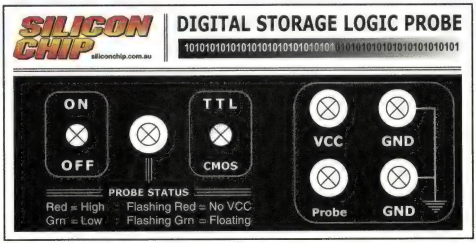
The software reads this and processes it accordingly. It will also write a data value of 56 decimal to the parallel port, taking pins 5,6 and 7 high – in turn, lighting up the green LED in bicolour LED3.

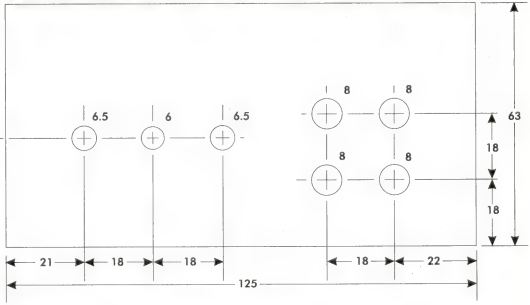
Detecting and processing a valid low level voltage is achieved in exactly the same way, except that IC1b, OPTO2 and pin 11 are involved.

Similarly, the software writes a value of 7 decimal to the port, sending pins 2, 3 and 4 high, lighting the red LED in LED3.

If the LED is flashing, (either colour) you have either of the two "error" states as shown on the front panel. **SC**

A selection of the connector cables you could need for this project. At left is a "curly cord" multimeter probe which is ideal as a data probe; the other cords have various types of clips for connecting to the circuit under test. All have banana plugs on one end.

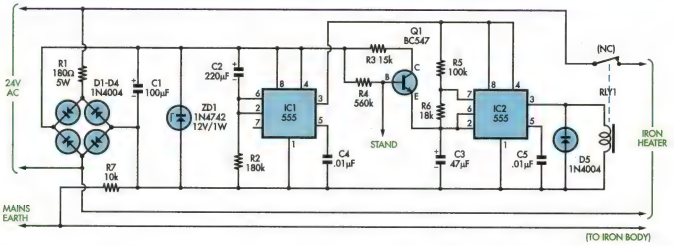




Figs. 5 & 6: 1:1 artwork for the front panel and a drilling template for the case. The panel artwork, along with the PC board pattern, can be downloaded from *www.siliconchip.com.au*

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions from readers are welcome and will be paid for at standard rates.



Soldering iron tip preserver

Although 60/40 solder melts at about 200°C, the tip temperature of a soldering iron should be at about 370°C. This is necessary to make a good quick joint, without the risk of overheating delicate components because the iron has to be kept on the joint for too long.

Unfortunately, at this temperature, the tip oxidises rapidly and needs constant cleaning. That's where this circuit can help – it keeps the soldering tip to just below 200°C while the iron is at rest. Oxidisation is then negligible and the iron can be brought back up to soldering temperature in just a few seconds when needed.

In addition, normal soldering operation, where the iron is returned to rest only momentarily, is unaffected because of the thermal inertia of the iron.

Two 555 timers (IC1 & IC2) form the heart of the circuit. IC1 is wired as a monostable and provides an initial warm-up time of about 45 seconds to bring the iron up to temperature. At the end of this period, its pin 3 output switches high and IC2 (which is wired in astable configuration) switches the iron on – via relay RLY1 – for about one second in six to maintain the standby temperature.

The presence of the iron in its stand is sensed by electrical contact between the two and some slight modification of the stand may be necessary to achieve this. When the iron is at rest, Q1's base is pulled low and so Q1 is off. Conversely, when the iron is out of its stand, Q1 turns on and pulls pins 2 & 6 of IC2 high, to inhibit its operation.

During this time, pin 3 of IC2 is low and so the iron is continuously powered via RLY1's normally closed (NC) contacts.

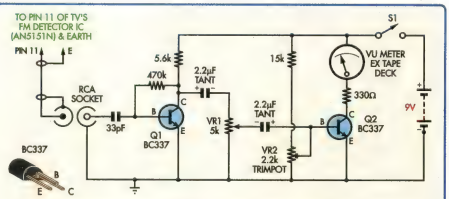
Note that the particular soldering iron that the circuit was designed for has its own 24V supply transformer. Other irons may need different power supply arrangements. The warm-up time and standby temperature can be varied by altering R2 and R5, as necessary.

Alan March,
North Turramurra, NSW. ($40)

TV relative signal strength meter

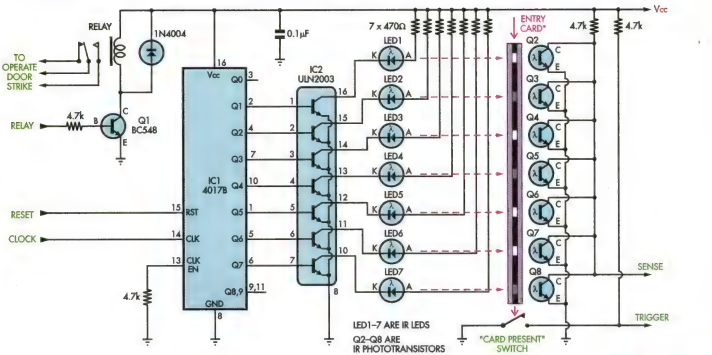
This circuit was designed to assist the installation of TV antennas. The signal is monitored using a portable TV set and this circuit monitors the output of the TV's FM detector IC via a shielded lead.

To initially calibrate the meter, adjust trimpot VR2 to zero the meter. Trimpot VR1 is a sensitivity control and can be set for a preset reading (ie, 0dB) or can be calibrated in millivolts.



Rotating the antenna for a minimum reading on the meter (indicating FM quieting) gives the optimum orientation for the antenna.

Ted Sherman,
Kawhia, NZ ($30)



Simple card access control system

This card access control system for medium-to-low security situations can be built at a relatively low cost and is more fun than a keypad. The circuit can be driven by the smallest of microcontrollers, say a PIC12C508A, and only requires simple assembly code to run.

The concept is quite simple – a cardboard or plastic card (with holes punched) is slipped between two PC boards separated by a plastic spacer. This spacer also helps to guide the access card into position.

When the access card is inserted all of the way to the back of the spacer, it hits a small rubber mat attached to a flexible metal clip which makes up one half of the "card present" switch. This flexible clip is forced against a small metal contact plate, resulting in the trigger line going low. This tells the microcontroller that a card is present.

The microcontroller can then pulse the clock line while reading the sense line. A low signal on the sense line indicates the presence of a hole.

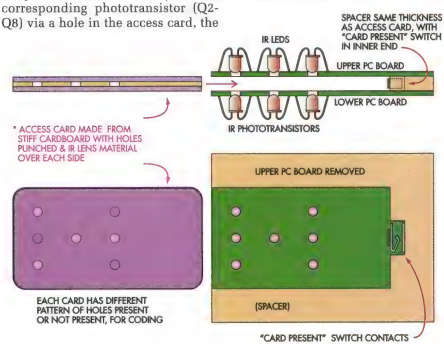
If you are using the unit in bright sunlight, it is advisable to read the sense line with an A/D converter input, to allow for variations in ambient light conditions. If no A/D converter input is available, a simple op amp input circuit would work just as well.

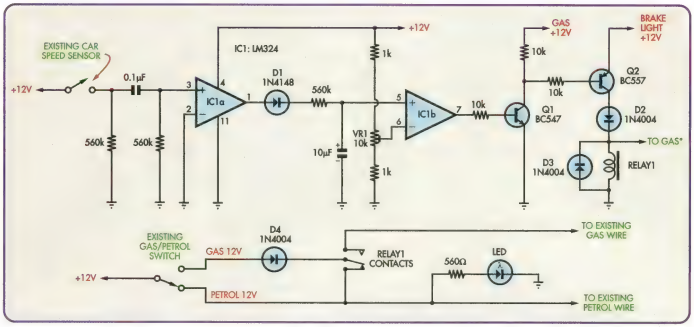
The circuit uses infrared LEDs and phototransistors, while the access card is covered with IR lens material on each side. This not only minimises problems with ambient light but also means that the holes in the access card are hidden (infrared lens material is readily available in sheets from Farnell Electronics).

IC1, a 4017B decade counter, counts up on every clock cycle (only one pin high at any time) from the microcontroller. Its outputs in turn drive LEDs 1-7 via IC2, a ULN2003 Darlington array. If a LED shines directly onto its corresponding phototransistor (Q2-Q8) via a hole in the access card, the phototransistor will turn on, pulling the sense line to ground.

The sense line is fed back to the microcontroller. If the correct sequence of phototransistors turns on, the microcontroller turns on transistor Q1 to activate the relay and the door strike mechanism.

David Kadow, Norwood, SA.





Petrol/gas switch for a Pajero

My current vehicle, a Pajero, was modified for dual fuel – ie, petrol and gas. However, it's necessary to run the vehicle on petrol at regular intervals to stop the injectors from clogging up.

This simple circuit allows the vehicle to be started using petrol and then automatically switches it to gas when the speed exceeds 45km/h and the brake pedal is pressed. Alternatively, the vehicle may be run on petrol simply by switching the existing petrol/gas switch to petrol.

You can also start the vehicle on gas by pressing the brake pedal while starting the vehicle.

The circuit is based on an LM324 dual op amp, with both op amps wired as comparators. It works like this: IC1a buffers the signal from the vehicle's speed sensor and drives an output filter network (D1, a 560kΩ resistor and a 10µF capacitor) to produce a DC voltage that's proportional to the vehicle's speed. This voltage is then applied to pin 5 of IC1b and compared with the voltage set by trimpot VR1.

When pin 7 of IC1b goes high, transistor Q1 turns on. This also turns on transistor Q2 when the brake pedal is pressed (pressing the brake pedal applies +12V from the brake light circuit to Q2's emitter). And when Q2 turns on, relay 1 turns on and its contacts switch to the gas position.

Trimpot VR1 must be adjusted so that IC1b's pin 7 output switches high when the desired trigger speed is reached (ie, 45km/h). In effect, the speed signal is AND'ed with the brake light signal to turn on the relay.

The vehicle has been running this circuit for several years now and is still running well, with no further injector cleans required.

J. Malnar,
Gordon, ACT. ($40)

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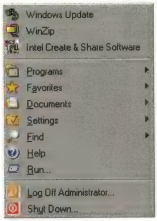
Spruce up your desktop with WinXP icons



DO YOU LIKE the look of Microsoft's new Windows XP operating system but cannot afford to upgrade? Here's how to spruce up your existing Win95/98/Me desktop by substituting WinXP-style icons. You can even change your wallpaper to an XP theme.

By GREG SWAIN

Along with many other improvements, Windows XP comes with an impressive new look and that includes redesigned icons. Unfortunately, many of us don't have the hardware that's necessary to run Windows XP and are better off sticking to Windows 95/98 or Windows Me for the time being.

You can, however, update your existing desktop by converting to WinXP-style icons. This can be done using one of several freeware/shareware utilities (eg, "XP Icon Raider") that are now available on the Internet. And if you must have it, you can install WinXP-theme wallpaper as well.

It's not a bad idea to back up your PC's registry before making these kinds of changes. If you don't now how to do this, go to **www.google.com** and search for ***Windows 98 backup registry*** (for example) – there will be plenty of "hits" with all the details on what to do.

To install XP icons on your Win98/Me desktop, first shut down all running applications, then go to:
www.skylarkutilities.com/program.pcs?xp-icon-raider
and download ***xpiraider.zip*** (134kB).

This unzips to three files (including a readme) and there's no installation routine as such – just double-click ***xpiraider.exe*** to bring up the dialog box shown in Fig.1, select which icons you wish to change and click the "Apply" button. Selecting "Class Icons" changes the icons for My Computer, My Documents, Network Neighborhood and the Recycle Bin; the "Shell Icons" button changes the appearance of disk drives and the Start Menu; and the "Associates" button updates many of the icons assigned to files.

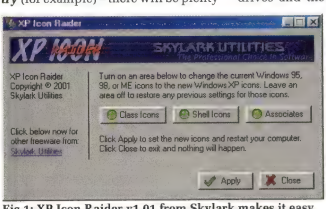
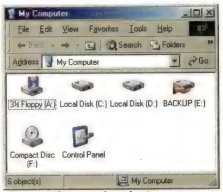


Fig.1: XP Icon Raider v1.01 from Skylark makes it easy for you to update the icons on your Win95/98/Me desktop to the XP look. It's also easy to change them back again.

When you click Apply, your PC will immediately perform a hard restart so make sure that you don't have any other programs running when you do this. If you want to revert to the old icons, just relaunch XP Icon Raider, turn off the appropriate buttons and click Apply once more.

Of course, the shiny new icons won't give you the considerable benefits that Windows XP has to offer. For that, you'll have to buy your own copy but if you have the hardware to run it, it's a worthwhile upgrade.

What about "XP-theme" wallpaper? There are lots to choose from at: **http://sardaulkar.planetarrakis.net/wallpaper.htm** Want more? – search the Internet. But personally, I think wallpaper is just there to slow your machine down. **SC**



Figs.2&3: here's what the icons on a Win98 desktop look like after running XP Icon Raider. Fig.4 at the top of the pages shows the updated Start menu.

Build this digital Thermometer/ thermostat

This thermometer uses a K-type thermocouple probe and is ideal for both industrial and in-home use. It can measure temperatures over the range from -55°C to 1200°C and includes under and over-temperature alarm outputs, which can be used to provide thermostatic control.

By JOHN CLARKE

ACCURATE TEMPERATURE measurements are vital during many industrial processes that involve heating or cooling. That's because too much or too little heat can give poor results, so it's necessary to ensure that the temperature is accurately controlled.

Kilns, for example, often operate at temperatures in excess of 1000°C and measuring temperatures of this order requires a probe that can cope with the heat. Further down the scale, a probe can also be used to measure the temperature of solder in a solder bath – eg, for tin-plating or wave-soldering PC boards. In the latter case, the solder must generally be maintained at a fairly constant temperature to ensure correct adhesion.

Accurate temperature measurements are also vital in the refrigeration industry. After all, many foods and other products can quickly spoil unless kept below specific temperatures.

This new Digital Thermometer/Thermostat can measure temperatures from -55°C to 1200°C, depending on the probe that's used. Its resolution is 0.1°C for measurements from -55°C to 199°C, and 1°C for measurements 200°C to 1200°C. However, the measurement accuracy itself depends on the calibration and the linearity of the probe used. Typically, the accuracy is within 2% of reading for meas-

urements up to 500°C.

Table 1 shows the expected readings from the Digital Thermometer for a given temperature.

A bi-colour LED situated on the front panel of the instrument is used as the temperature "alarm". It simply changes colour when the measured temperature either rises above or drops below a preset "alarm" temperature (as set by a pushbutton switch). At the same time, a small piezoelectric buzzer inside the case provides an audible alarm when the preset temperature is reached.

The buzzer can be left out of circuit if an audible alarm is not required.

The unit also provides two outputs to drive external relays (if required) for thermostatic control. One of these outputs is used to control the "under-temperature" relay, while the other controls the "over-temperature" relay. In use, the relays could typically be used to automatically switch heating elements, fans or refrigeration units on or off.

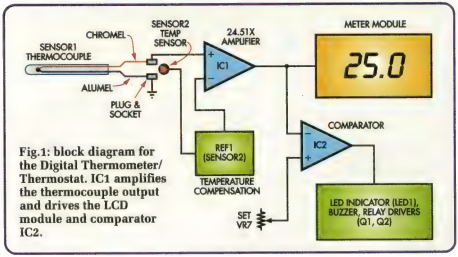


Fig.1: block diagram for the Digital Thermometer/ Thermostat. IC1 amplifies the thermocouple output and drives the LCD module and comparator IC2.

K-type thermocouple

As mentioned above, this design uses a K-type thermocouple (a thermocouple consists of two dissimilar metals) as the temperature probe. A K-type thermocouple uses an alloy of chrome and nickel (called Chromel) for one wire and an alloy of aluminium, manganese, silicon and nickel (called Alumel) for the second. The two wires are insulated and only make contact at one end – ie, at the temperature probe end. The other ends of the wires are separately connected to a 2-pin plug

Basically, a thermocouple's operation relies on the principle that two dissimilar metals produce a voltage which is dependent on temperature. Fig.1 shows how the thermocouple (Sensor1) is connected to the thermometer circuit.

A K-type thermocouple produces a voltage output that changes by 40.44µV/°C. This change in output per degree C is called the "Seebeck Coefficient" – it refers to the output change that occurs due to the temperature difference between the probe end and the plug end of the thermocouple. If both ends are at the same temperature, there will be no output voltage.

It follows that if we know the temperature at the plug end of the thermocouple, we can calculate the temperature at the probe since we also know the Seeback coefficient. For example, if the plug end is held at 0°C, the output will increase by 40.44µV for every 1°C above zero. Similarly, the output will decrease by 40.44µV for every 1°C drop in temperature.

This means that the output voltage from the thermocouple will be at 404.4mV at 10°C and at 1.01mV at 25°C.

If we then multiply the thermocouple output by 24.73 using an amplifier (op amp IC1), we effectively convert the output from 40.44µV/°C to 1mV/°C. This can then be used to give a direct readout of the temperature on a panel meter.

Compensating the output

In practice, our thermometer operates somewhat differently because we don't keep the plug end of the thermocouple at 0°C. Although this could be done using an ice bath that is constantly stirred and topped up with ice, it's too cumbersome to be a practical proposition. Instead, we compensate the thermocouple output by firstly measuring the temperature at the plug end using a semiconductor sensor (Sensor2 in Fig.1). We then add 40.44µV for every 1°C that the thermocouple plug end is above 0°C.

Normally, if the thermocouple plug is at 25°C (ie, at about room temperature), its output will be 1.01mV lower than it would be if it were at 0°C. By adding an extra 1.01mV to the reading (ie, 25 x 40.44µV), we obtain the correct result without having to keep the plug end at 0°C.

Note that there are several dissimilar metal junctions within the connections between the thermocouple plug and amplifier. These include the Chromel to copper junction and the Alumel to copper junction on the PC board itself. However, these do not contribute to the overall voltage reading after calibration provided they are all kept at the same temperature.

As a result, the PC board has been designed to help maintain similar temperatures at these junctions by making the copper connections all the same size. And once the PC board is installed inside its case, the inside temperature will remain fairly constant.

Note, however, that if the thermocouple lead is extended, it is necessary to use the same thermocouple wire for the whole length between the probe and plug.

In addition, an op amp with an extremely low input offset voltage change with temperature is used for

MAIN FEATURES

- -55°C to 1200°C reading (dependent on probe)
- 0.1°C resolution to 199.9°C
- 1°C resolution to 1200°C
- Under and over temperature alarm indication
- Suitable for driving relays for thermostat control
- Adjustable alarm temperature
- AC plugpack or 2 x 9V battery operation
- LCD readout
- Compact case

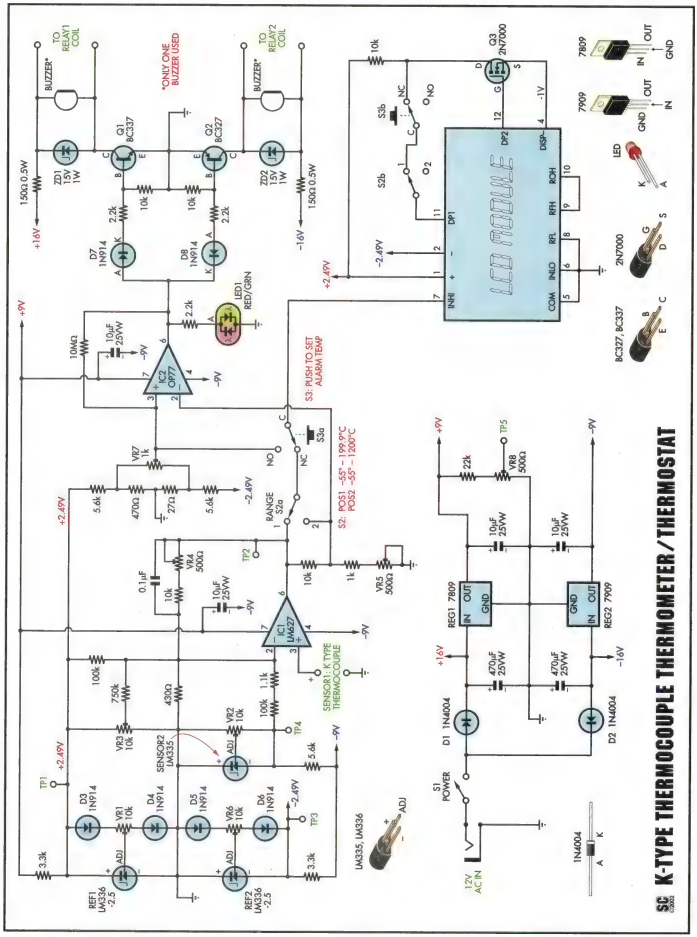

K-TYPE THERMOCOUPLE THERMOMETER/THERMOSTAT
SC
LED MODULE
LED1 RED/GRN
IC1 LM627
IC2 OP77
Q1 BC337
Q2 BC327
Q3 2N7000
D1 1N4004
D2 1N4004
REG1 7809
REG2 7909
S1 POWER
12V AC IN
1N4004
S2: POS1 -55° - 199.9°C
POS2 -55° - 1200°C
S3: PUSH TO SET ALARM TEMP
SENSOR1: K TYPE THERMOCOUPLE
SENSOR2 LM335
REF1 LM336 -2.5
REF2 LM336 -2.5
LM335, LM336
BC327, BC337
2N7000
7809
7909
TO RELAY1 COIL
TO RELAY2 COIL
BUZZER*
*ONLY ONE BUZZER USED
+16V
-16V
+9V
-9V
+2.49V
-2.49V

Fig.2 (left): the complete circuit diagram for the Digital Thermometer/ Thermostat. IC1 acts as a non-inverting amplifier with a gain of 24.73 for Sensor1 (a K-type thermocouple), as an inverting amplifier with a gain of 0.1009 for Sensor2 and as an inverting amplifier with a gain of 0.1106 for REF1. IC2 compares the output of IC1 with a reference voltage derived from VR7 and drives the under and over-temperature alarm circuits (Q1, Q2 and a buzzer).

IC1 (LM627). In fact, this op amp has a maximum drift of 0.6µV/°C between -25°C and 85°C. Assuming that its temperature changes by 40°C, this would contribute a maximum of 24µV to the thermocouple output – equivalent to just under 0.6°C.

As shown in Fig.1, IC1's output is fed to comparator IC2. This comparator also monitors the voltage at the wiper of the Set potentiometer (VR7). If the temperature goes above the set value, then IC2's output goes low. Conversely, if the temperature goes below the set value, the comparator's output goes high. This output drives the bi-colour LED and also drives two transistors stages to control the relays and the buzzer.

Note that the buzzer can be wired in one of two positions. In one position, it sounds only when the temperature rises above the set value. Conversely, in the other position, it sounds only when the temperature falls below the set value.

Note also that we have specified an OP77GP (or OP07CN) op amp for IC2. This device has similar specifications to the LM627 but note that, because of its internal diode clamps, we cannot use an LM627 for IC2.

The OP77GP and OP07CN have clamping too but it is implemented differently. As a result, the op amp's input impedance always remains high which means that it doesn't load down any voltages at its inputs.

And here's an interesting twist: although we cannot substitute an LM627 for IC2, the reverse isn't true for IC1! An OP77GP or OP07CN can be used instead of the LM627. Watch this point when building the PC board.

Circuit details

Refer now to Fig.2 for the complete circuit of the K-Type Thermocouple Thermometer/Thermostat. As before, IC1 provides the gain for the thermocouple output while Sensor 2 and REF1 provide the compensation for the thermocouple probe.

As shown, the thermocouple's output is fed to IC1's non-inverting input (pin 3). Thus, IC1 functions as a non-inverting amplifier for thermocouple signals. Its gain is set by the feedback components connected between pins 6 and 2, together with the 430Ω resistor to ground, and is adjusted using VR4.

As explained above, this stage is set for a gain of 24.73 (ie, to give 1mV/°C at pin 6). In practice, this involves adjusting VR4 (during calibration) for a resistance of 204Ω (ie, 1 + 10,204/ 430 = 24.73).

Sensor2, an LM335 temperature sensor, is used to measure the temperature at the plug end of the thermocouple. In operation, this device provides a nominal 10mV/°C output. It is supplied with current from the -9V rail via a 5.6kΩ resistor and its output (at the negative terminal) is fed to pin 2 of IC1 via 100kΩ and 1.1kΩ resistors.

As a result, IC1 functions as an inverting op amp stage for signals from Sensor 2. In this case, its gain is 0.1009 (ie, 10204/(100,000 + 1100) so Sensor2's nominal 10mV/°C output is reduced to 1.009mV/°C at IC1's output.

Trimpot VR2 allows Sensor2 to be adjusted so that IC1's output in fact changes by 1mV/°C. This matches the 1mV/°C output from IC1 due to the thermocouple and so Sensor2 provides temperature compensation.

Offset voltage

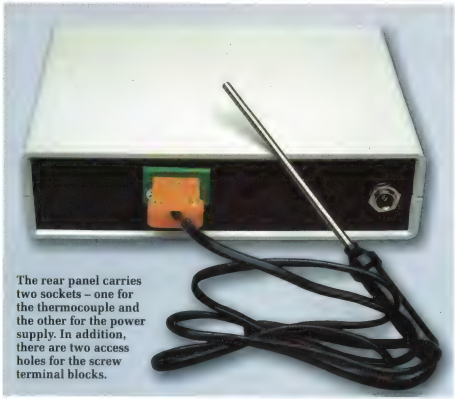
One problem with Sensor2 is that its output at 0°C is 2.73V as opposed to 0V from the thermocouple. So while Sensor2 can provide the required 1mV/°C temperature compensation, it has a 2.73V offset voltage which must be corrected. This translates to an offset voltage of 275.5mV at IC1's output (since IC1 has a gain of 0.1009 for signals from Sensor2).

This offset voltage is corrected using voltage reference REF1. This device delivers a nominal 2.5V but this can be adjusted over a small range using VR1 at it ADJ (adjust) terminal. Diodes D3 and D4 provide temperature compensation for the sensor, so that its output remains constant over a wide temperature range.

In practice, VR1 is used to adjust REF1 to give 2.490V, as this provides

Table 1: Thermocouple Calibration

Thermocouple Temperature (Degrees C)	Thermocouple Output (mV/(Degree C))	Display Reading (Degrees C)
-60	-2.243	-55.5
-40	-1.527	-37.8
-20	-0.777	-19.2
-10	-0.392	-9.7
0	0	0
10	0.397	9.8
20	0.798	19.7
25	1.000	24.7
30	1.203	29.8
40	1.611	39.8
50	2.022	50.0
60	2.436	60.2
80	3.266	80.8
100	4.095	101.3
120	4.919	121.6
140	5.733	141.8
160	6.539	161.7
180	7.338	181.5
200	8.137	201.2
220	8.938	221.0
240	9.745	241.0
260	10.560	261.1
280	11.381	281.5
300	12.207	301.9
320	13.039	322.5
340	13.874	343.1
360	14.712	363.8
380	15.552	384.6
400	16.395	405.4
420	17.241	426.4
440	18.088	447.3
460	18.938	468.3
480	19.788	489.4
500	20.640	510.4
520	21.493	531.5
540	22.346	552.6
560	23.198	573.7
580	24.050	594.8
600	24.902	615.8
620	25.751	636.8
640	26.599	657.8
660	27.445	678.7
680	28.288	699.6
700	29.128	720.3
720	29.965	741.0
740	30.799	761.7
750	31.214	771.9
760	31.629	782.2
780	32.455	802.6
800	33.277	822.9
820	34.095	843.2
840	34.909	863.3
860	35.718	883.3
880	36.524	903.2
900	37.325	923.0
920	38.122	942.8
940	38.915	962.4
960	39.703	981.9
980	40.488	1001.3
1000	41.269	1020.6
1020	42.045	1039.8
1040	42.817	1058.9
1060	43.585	1077.9
1080	44.349	1096.8
1100	45.108	1115.5
1120	45.863	1134.2
1140	46.612	1152.7
1160	47.356	1171.1
1180	48.095	1189.4
1200	48.828	1207.5



The rear panel carries two sockets – one for the thermocouple and the other for the power supply. In addition, there are two access holes for the screw terminal blocks.

the lowest change in value with temperature.

This 2.49V output is fed to pin 2 of IC1 via a network consisting of a 100kΩ resistor, trimpot VR3 and a 750kΩ resistor. VR3 allows IC1's gain to be precisely adjusted for this signal, so that it cancels the 275.5mV offset generated by Sensor2.

Note that the 750kΩ resistor and VR3 also have some effect on the gain of IC1 for the thermocouple (since they are effectively in parallel with the 430Ω resistor). However, their effect is really quite small (less than .06%) and, in any case, is easily corrected during calibration.

Range switch

In summary then, IC1 provides us with a 1mV/°C output, as measured by the thermocouple probe. This means that at 200°C, its pin 6 output will be at 200mV which is sufficient to overrange a 200mV LCD meter (as used here).

Consequently, a voltage divider is included immediately after IC1, so that the meter can display temperature measurements above 200°C – ie, up to 1200°C. This divider consists of a 10kΩ resistor, a 1kΩ resistor and a 500Ω trimpot (VR2) connected in series to ground. In practice ,VR2 is set to 111Ω, so that IC1's output is divided by 10 at the junction of the 10kΩ and 1kΩ resistors.

Range switch S2a is used to select between the two temperature ranges (ie, either -55°C to 199.9°C or -55°C to 1200°C). From there, the signal is applied to the pin 7 input (INHI) of the LCD module. In addition, the divided signal on position 2 of the range switch is fed to the inverting input of comparator IC2.

Alarm indication

IC2 compares this divided signal with the voltage on its non-inverting (pin 3) input, as set by trimpot VR7 (Alarm Set). This trimpot is fed by a divider network connected between the +2.49V and -2.49V rails and to ground. It allows the voltage on pin 3 to be adjusted between -5.5mV and +120mV (in practice, it's a little more than this), corresponding to setting the alarm threshold between -55°C and +1200°C.

The -2.49V rail is obtained using another LM336-2.5 reference (REF2). This works in a similar fashion to REF1, with VR6 setting the output to -2.49V.

If the voltage at pin 2 of IC2 is higher than the voltage on pin 3, the pin 6 output goes negative and sits close to the -9V supply rail. This indicates the "over-temperature" condition and turn on the green LED in LED1. At the same time, D8 is forward biased and PNP transistor Q2 turns on and drives the buzzer (if connected). In addition, Q2 drives Relay 2 (if con-

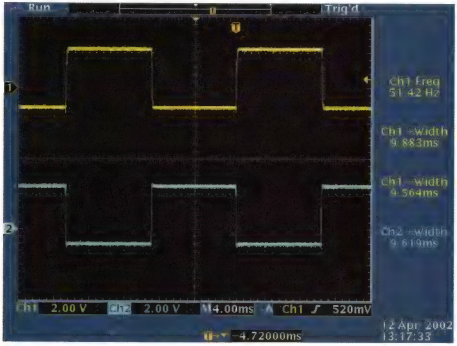


Fig.3: the top trace is this scope shot shows the 50Hz square-wave drive to the unused decimal point DP2. This square wave is in phase with the LCD backplane signal (not accessible from the pins of the LCD module). The lower trace is the inverted (out-of-phase) signal at the drain of Mosfet Q3. This out-of-phase signal drives decimal point (DP1) when the -55°C to 199.9°C range is selected.

nected) via a 150Ω resistor in series with the -16V supply.

Zener diode ZD2 is included to limit the voltage across the buzzer if a relay is not connected.

Conversely, if pin 2 is lower than pin 3, IC2's output will swing close to the +9V rail. This indicates the "under-temperature" condition and turns on the red LED in LED1. It also turns on Q1 to drive the buzzer and Relay 1 (if these are connected).

As before, a 150Ω 0.5W resistor is included in series with the supply rail to the relay. This resistor value is suitable for use with 12V relays with coil resistances ranging from 285Ω to 400Ω.

Note that although two buzzers are shown on the circuit, only one is used in practice. If an audible alarm is required when the temperature goes above the set level, connect the buzzer to Q2. Alternatively, if an audible alarm is required when the temperature drops below a certain value, connect the buzzer to Q1.

The 10MΩ feedback resistor between pins 3 & 6 of IC2 provides hysteresis for the comparator. In operation, the resistor pulls the voltage on pin 3 an extra 350μV higher when pin 6 goes high and lower by about 350μV when pin 6 goes low. This set the hysteresis to 3.5°C but this can be increased by using a smaller value for the feedback resistor.

Setting the alarm temperature

Pressing switch S3a connects VR7's wiper directly to pin 7 of the LCD module. This allows the module to indicate the set alarm temperature. This can be altered by using a small screwdriver to vary VR7 (which is a 10-turn trimpot) through a small adjustment hole in the front panel.

LCD module

The LCD module is operated from a nominal 5V supply using the +2.49V and -2.49V reference voltages provided by REF1 and REF2. As shown, the COM, RFL (Ref-Low) and INLO (In-Low) inputs all connect to ground, while the ROH (Reference) output at pin 10 sits 100mV above ground and provides the 200mV (ie, twice the reference voltage) full-scale range for the display. This pin is connected to the RFH (Ref-High) input.

Unfortunately, the LCD module used in the prototype (Jaycar Cat.QP-5570) doesn't have an output that can directly drive the decimal points. As a result, Mosfet Q3 has been included to drive decimal point DP1.

In order to turn DP1 on, it must be driven using an inverted version of the LCD's backplane signal. This signal operates at about 50Hz. The voltage swings between the DISP- level (which is about -1V below ground) and the 2.49V positive supply. This gives a square-wave drive of 3.49V peak-to-peak.

Q3 monitors the high-impedance backplane signal on one of the unused

Parts List

1 PC board, code 04208021, 117 x 102mm
1 plastic case, 140 x 110 x 35mm
1 front panel label, 132 x 28mm
1 12VAC 100mA plugpack
1 LCD 3.5-digit panel meter (Jaycar QP-5570, Altronics Q-0571 – see text)
1 'K' type thermocouple with probe (Sensor1)
1 'K' type thermocouple panel socket (Farnell Cat 708-7949)
2 2-way PC mount screw terminals (5.04mm pin spacing)
1 DC power socket
1 mini PC-mount buzzer (7.6mm pin spacing)
1 12VAC 100mA plugpack
1 SPDT toggle switch (S1)
1 DPDT toggle switch (S2)
1 DPDT momentary pushbutton switch (S3)
1 10-way pin header socket (2.54mm pin spacing)
1 2-way pin header socket (2.54mm pin spacing)
1 5mm LED bezel
1 200mm length of red hookup wire
1 200mm length of black hookup wire
1 200mm length of yellow hookup wire
1 200mm length of white hookup wire
1 200mm length of green hookup wire
1 150mm length of 0.8mm tinned copper wire
4 M3 x 6mm screws
4 50mm long cable ties
19 PC stakes

Semiconductors
1 LM627CN, OP27GP, OP77GP or OP07CN op amp (IC1)
1 OP77GP or OP07CN op amp (IC2)
2 LM336-2.5 2.5V reference (REF1,REF2)
1 LM335 temperature sensor (Sensor2)
1 BC337 NPN transistor (Q1)
1 BC327 PNP transistor (Q2)
1 2N7000 N channel signal Mosfet (Q3) (for decimal point switching on LCD)
1 7809 regulator (REG1)
1 7909 regulator (REG2)
2 1N4004 1A diodes (D1,D2)
6 1N4148, 1N914 diodes (D3-D8)
2 15V 1W zener diodes (ZD1,ZD2)
1 5mm bicoloured LED (2-leads) LED1

Capacitors
2 470μF 25VW PC electrolytic
4 10μF 25VW PC electrolytic
1 0.1μF MKT polyester (code 100n or 104)

Resistors (0.25W, 1%, 50ppm/°C or better temperature coefficient)

1 10MΩ	3 2.2kΩ
1 750kΩ	1 1.1kΩ
2 100kΩ	1 1kΩ
1 22kΩ	1 470Ω
6 10kΩ	1 430Ω
3 5.6kΩ	2 150Ω 0.5W
2 3.3kΩ	1 27Ω

Trimpots
4 10kΩ horizontal cermet trimpots (VR1, VR2, VR3, VR6) (code 103)
1 1kΩ horizontal multi-turn trimpot (VR7) (code 102)
3 500Ω horizontal cermet trimpot (VR4, VR5, VR8) (code 501)

Extra parts required for battery operation
2 9V batteries
2 battery snap-on connectors
2 battery clip holders (Altronics S 5050)
1 DPDT toggle switch (S1)
2 M3 x 6mm screws and nuts

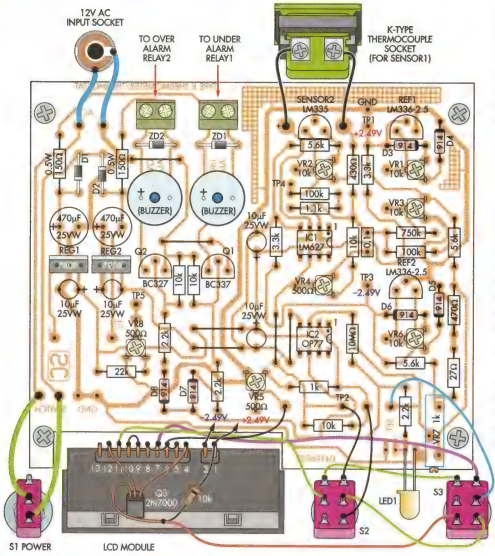


Fig.4: follow this wiring diagram to build the Digital Thermometer/Thermostat but note that only one buzzer is installed in the positions indicated (see text). Note also that PC stakes are installed at all external wiring positions and at the test points (TP). Q3 and its associated 10kΩ resistor can be omitted for panel meters with a decimal point driver pin (see Fig.8).

decimal points (in this case, DP2 at pin 12). When the voltage goes high, Q3 switches on and the drain voltage is pulled to the -1V level. Conversely, when the backplane signal goes low, Q3 switches off and the drain is pulled to the +2.49V supply via a 10kΩ resistor.

As a result, the drain voltage is an inversion of the backplane signal and this drives decimal point DP1 via range switch S2b and Set switch S3b.

Note that while the decimal point can be displayed by connecting its pin directly to the positive supply, it is not a recommended practice. There are a couple of reasons for this: first, it places a DC voltage on the segment which can shorten the life of the LCD; and second, the decimal point segment would appear rather washed out instead of fully black.

Alternative LCD panel meter

By contrast, the alternative LCD module from Altronics (Cat. Q-0571) does include a decimal point drive output (pin 10). This means that Q3 and its associated 10kΩ resistor are no longer required if the Altronics module is used. Instead, the decimal point driver output at pin 10 is connected directly to the NC contact of switch S3b.

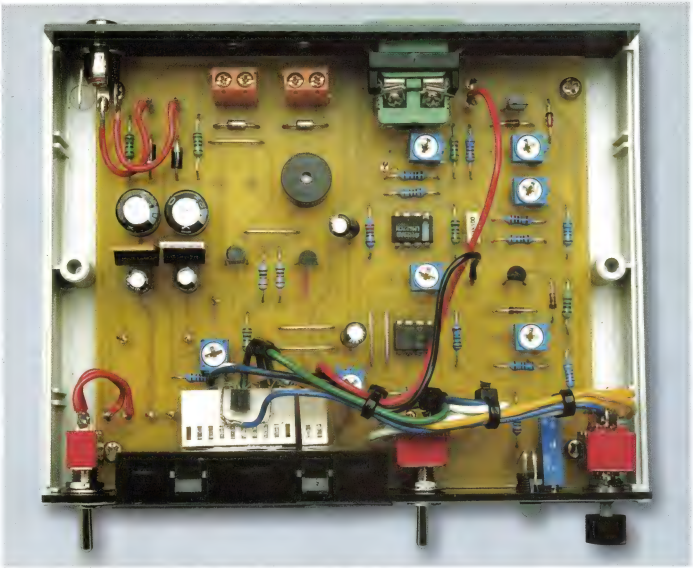
Fig.8 shows how the Altronics module is used. Note the different pin numbering.

Power supply

Power for the circuit is derived from a 12V AC plugpack. Its output is rectified using D1 and D2 to give nominal

Table 2: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	10MΩ	brown black blue brown	brown black black green brown
❑	1	750kΩ	violet green yellow brown	violet green black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	1	22kΩ	red red orange brown	red red black red brown
❑	6	10kΩ	brown black orange brown	brown black black red brown
❑	3	5.6kΩ	green blue red brown	green blue black brown brown
❑	2	3.3kΩ	orange orange red brown	orange orange black brown brown
❑	3	2.2kΩ	red red red brown	red red black brown brown
❑	1	1.1kΩ	brown brown red brown	brown brown black brown brown
❑	1	1kΩ	brown black red brown	brown black black brown brown
❑	1	470Ω	yellow violet brown brown	yellow violet black black brown
❑	1	430Ω	yellow orange brown brown	yellow orange black black brown
❑	2	150Ω	brown green brown brown	brown green black black brown
❑	1	27Ω	red violet black brown	red violet black gold brown



This view shows the completed unit with the buzzer in the under-temperature alarm position. Use plastic cable ties to secure the wiring to the LCD module and switches.

±16V DC rails. These rails are then filtered using 470µF electrolytic capacitors and applied to regulators REG1 and REG2 to derive ±9V rails.

Alternatively, the ±9V rails can be obtained directly from two 9V batteries.

Trimpot VR8 is used only for calibration and is not usually used in-circuit. During calibration, it is used to provide a small DC voltage to the non-inverting input of IC1. IC1's output is then measured while VR4 is adjusted to give the required gain (more on this later).

Construction

The unit is built on a PC board coded 04208021 and this fits into a low-profile plastic case measuring 140 x 110 x 35mm (W x D x H).

Begin by checking the PC board for breaks or shorts in the copper tracks and check that the holes sizes for the larger components are correct. The PC stakes (used at all external wiring positions and test points) should be a tight fit into their mounting holes, while 1.5mm holes are required for the screw terminal blocks.

Note that there is a rectangular cutout at the front of the PC board – see Fig.4. This cutout provides clearance for the bottom of the LCD module. It allows the LCD module to be slid down far enough to clear the moulded ridges at the front of the case lid.

Fig.4 shows how to build the plugpack-operated version, while Fig.5 shows the changes required for the battery-operated version. Note that the latter does not require REG1, REG2, D1, D2, the 150Ω resistors or the 470µF capacitors.

Install the PC stakes, resistors and wire links first. Table 2 shows the resistor colour codes but it's also a good idea to check the resistor values using a digital multimeter.

The diodes can go in next, followed by zener diodes ZD1 and ZD2. That done, install LED1 at maximum lead length, taking care to ensure that it is correctly oriented. It is later bent over at right angles and clipped into a matching bezel on the front panel.

Now for the semiconductors. These include Sensor 2, REF1, REF2, regulators REG1 & REG2, transistors Q1 & Q2 and the two ICs. Make sure that all these parts are correctly oriented and that you don't get any of them mixed up.

The capacitors and the screw-terminal blocks can now be installed, along with the buzzer. Install the

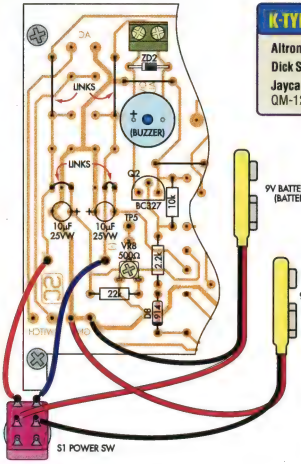


Fig.5: here's how to modify the PC board assembly for battery operation. Regulators REG1 & REG2 and the two 150Ω resistors are replaced by wire links, while diodes D1 & D2 and the 470µF capacitors are left out of circuit.

K-TYPE PROBE AVAILABILITY

Altronics: Q 1092 (-20°C to 1200°C)
Dick Smith: Q-1438 (-50°C to 1200°C)
Jaycar: QM-1282 (-55°C to 1200°C); QM-1283 (-40°C to 250°C)

buzzer in the under-temperature alarm position (at right) if you want it to sound when the temperature falls below the set value. Conversely, install it in the over-temperature alarm position if you want it to sound when the temperature rises above the set value.

Final assembly

Now for the final assembly. The first step is to secure the PC board to the base of the case using 4 x M3 screws which screw into the integral pillars.

That done, work can begin on the front panel. Fig.5 can be used as a drilling template – you will have to drill holes to accept the three switches and the LED bezel, plus an extra hole to provide access to VR7. In addition, you have to make a large cutout to accept the LCD module.

The cutout for the display can be made by first drilling a series of holes around the inside perimeter of the cutout hole. The piece can then be broken away and the job filed for a smooth finish.

Once that's done, affix the front panel label and install the switches and the LED bezel. The front panel can then be slid into position and LED1 bent over and pushed through the bezel until it clips into place.

The LCD module can now be installed and the wiring completed as shown in Fig.4. We used two header sockets (one 2-way and one 10-way) for the connections to the LCD module, so that it can be easily removed. Alternatively, the leads could be directly soldered to the pins on the module as shown in Fig.4.

Note that Q3 and its associated 10kΩ resistor are either mounted on the cable entry side of the pin header socket (see photo) or soldered directly to the pins of the LCD module.

Use cable ties to secure the wiring, as shown. If you are building the battery version, the two 9V batteries are secured to the lid using metal battery clips. One side of each clip is removed, after which they are secured to the side of the case using M3 x 6mm countersunk screws and nuts.

The rear panel will require holes for the power socket and the thermocouple socket, plus access holes through which to pass leads to the screw terminal blocks (to wire external relays).

The thermocouple socket is mounted directly in-line with Sensor2. It should be mounted fairly high up on the rear panel (about 4mm from the top), since it sits directly over Sensor2 when the rear panel is in place.

You will need to cut a 17 x 11mm hole to accept the sensor socket. This can be done by first marking out the cutout area, then drilling a series of small holes around the inside perimeter, knocking out the centre piece and filing to a smooth finish. Once that's done, the socket can be clamped into position and short lengths of tinned copper wire run between its terminals and the adjacent stakes on the PC board.

Finally, complete the construction by running the wiring to the AC power socket.

Testing

Before doing anything else, it's a good idea to go over the PC board and check that the assembly is correct. In particular, check that all parts are in the correct locations and that they are correctly oriented. You should also carefully check the wiring to the LCD module.

That done, apply power and check that the LCD shows a reading. Now, using a multimeter, check that there is a nominal +9V at pin 7 of IC1 & IC2 and -9V at pin 4 of IC1 & IC2. If these readings are correct, check that there

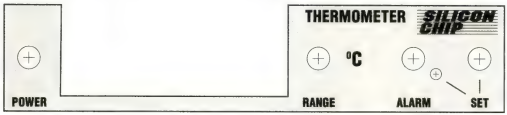


Fig.6: this full-size artwork can be used as a drilling template for the front panel.

The way in which the thermocouple socket is mounted and its leads connected to stakes on the PC board can be clearly seen here. Note the holes in the rear panel opposite the screw terminal blocks.

is approximately +2.5V at TP1 and -2.5V at TP3.

Note that these voltages could be 100mV higher or lower than the nominated values at this stage. They should all be measured with the common lead from your multimeter attached to the GND terminal near Sensor2. If everything is correct so far, you can now carry out the following steps to calibrate the instrument:

(1) Adjust VR1 for +2.490V at TP1. Similarly, adjust VR6 for -2.490V at TP3.

(2) Switch off and connect a clip lead between Sensor1's plus (+) terminal (ie, pin 3 of IC1) and ground. Also, short TP1 and TP4 to ground.

(3) Apply power and measure the voltage at TP2 using a multimeter set to read millivolts. Write this offset voltage down, then switch off and remove the short at Sensor1's plus terminal.

(4) Connect a clip lead from Sensor1's plus terminal to TP5. Reapply power and adjust VR8 for a reading of 100mV at TP5.

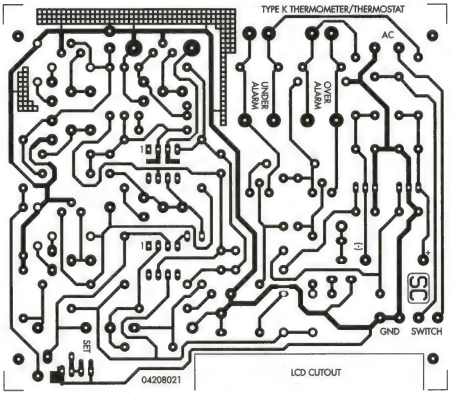
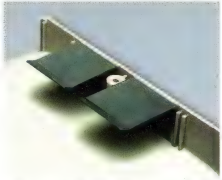


Fig.7: this is the full-size etching pattern for the PC board.



Here's how the two metal clips are attached to the case lid for the battery-powered version. It's also a good idea to place some foam rubber over the PC board, so that the batteries cannot short anything out if they come loose.

(5) Monitor the voltage at TP2 and adjust VR4 for a reading that's equal to the voltage at TP5 x 24.73 + the offset voltage that was written down. For example, if TP5 is set to exactly 100mV and the recorded offset voltage is 0.5mV, then VR4 should be adjusted so that the voltage at TP2 is 100mV x 24.73 + 0.5mV, or 2.4735V.

Note that it may be difficult to set VR8 to provide an exact 100mV output at TP5. In that case, just set the value to somewhere around this value and multiply it by 24.73. You then add the offset voltage and adjust VR4 for this reading at TP2.

(6) Switch off and again short Sensor1's plus terminal to ground. Disconnect the short for TP4 but leave the short to ground at TP1.

(7) Using a reference thermometer of known accuracy, check its reading of the ambient temperature in °C. Add 273 to this measured value (to convert from °C to the Kelvin scale) and label this value as millivolts. Add the initial offset voltage of IC1 to this value, then switch on and adjust VR2 so that TP2 equals this value in mV.

(8) Switch off and remove the short across REF1 by disconnecting TP1 from ground. Also, disconnect the short on the plus terminal of Sensor1.

(9) Connect Sensor1 to its socket and reapply power. Adjust VR3 so that the voltage at TP2 in mV is equal to the current temperature in °C as measured on the reference thermometer (eg, if the ambient temperature is 25°C, adjust VR3 so that TP2 is at 25mV).

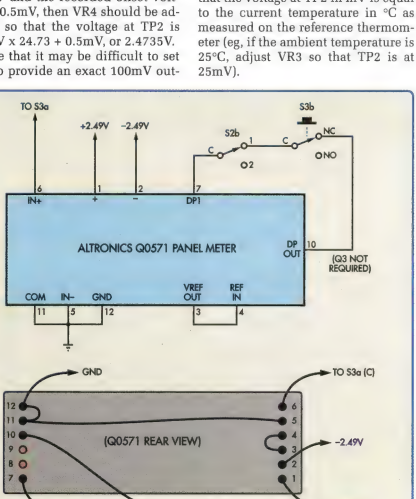


Fig.8: here's how to use the Altronics Q0571 LCD panel meter in the Digital Thermometer/Thermostat. Note that Q3 and its associated 10kΩ resistor are no longer required.

DSE KIT HAS LED PANEL METER

The Dick Smith Electronics kit for this project will be supplied with a 3.5-digit LED panel meter (Cat. Q2230), instead of an LCD panel meter. This ensures a bright display but also means that the DSE kit is suitable for plugpack operation only.

A few minor circuit changes were required to accommodate the LED panel meter. These design changes, along with a slightly modified PC board, have all been carried out by Silicon Chip Publications. Full details are included in the DSE kit.

Note: as it stands, the DSE 3.5-Digit LCD Panel Meter (Cat. Q2220) is not suitable for use in this design.

Note that this reading should also now be displayed on the LCD. On the low range, it should be displayed with 0.1°C resolution, with the decimal point lit. The high range reading will be displayed with 1°C resolution. Adjust VR5 so that the readings are the same on both ranges.

(10) Press S2 and check that the alarm set temperature range can be adjusted between -55°C and 1200°C using VR7.

Better accuracy can be gained by repeating this entire calibration procedure again. That's because the adjustment of VR3 can slightly alter the overall calibration. Also, better accuracy will be achieved if the circuit is allowed to stabilise for several minutes each time power is reapplied and when components are allowed to cool to normal operating temperatures after being heated by a soldering iron (eg, as can occur during the removal of shorting leads).

A 12V relay can be connected to the over or under-temperature alarm terminal block, so that it can be used to switch in a heating element or a compressor for cooling. Make sure that the relay is adequately rated for the job and note that the leads connecting to the relay contacts must be kept electrically isolated from the coil leads, particularly if mains is to be switched.

By the way, we don't recommend that you attempt to wire up a relay to switch mains voltages unless you are very experienced with high voltage work and know exactly what you are doing. In fact, that's a job that's best left to a licensed electrician. **SC**

Jaycar ELECTRONICS

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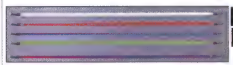
These flickerless fluoro tubes produce an incredible amount of light for their tiny size of just 4mm dia. We have 2 different lengths 100mm and 300mm, with 5 colours to choose from. You can put them behind air vents, under dashboards, above stereos, around sub boxes, under seats the list goes on. Each tube is powered by a small inverter that draws around 370mA of current and you require one inverter per tube. Each inverter is powered by 12V. So brighten up your car today the CCFL way.



NEW PRODUCT

CCFL TUBES	100mm $11.95ea	300mm $19.95ea
WHITE	Cat. SL-2860	Cat. SL-2880
RED	Cat. SL-2861	Cat. SL-2881
BLUE	Cat. SL-2862	Cat. SL-2882
GREEN	Cat. SL-2864	Cat. SL-2884
U.V	Cat. SL-2865	Cat. SL-2885

CCFL Inverters to Suit:
100mm Cat. SL-2868 $9.95ea
300mm Cat. SL-2888 $12.95ea

ARRIVING IN STOCK MID AUGUST

High Quality LED Torch

WITH DIMMING & FLASHING FEATURE
This torch is unique in various ways. It is microprocessor controlled with a built in flasher circuit, as well as a dimmer circuit. This torch is the first we have seen that runs off a 9v battery which is supplied. The case is made from stainless steel, with the handle made from soft plastic. MADE IN GERMANY.
*Size 93(L) x 39(W)

NEW PRODUCT

Cat. ST-3330 $49.95

Sine Wave Inverters 12V-1000W/24V-1500W Electrically Isolated Powertech

These are some of the most sophisticated Sinewave Inverters we have seen. Designed to be used in fixed installations, they offer high performance, electrical isolation between battery and mains voltages, and durable metal construction. They feature high efficiency, fan cooling, short circuit protection, battery reverse protection and overload shutdown. They offer the best in reliability & safety. For details see page 137 of our 2002 catalogue.

NEW PRODUCT

1000W 12V Cat. MI-5090 $1099
1500W 24V Cat. MI-5095 $1395

Laptop Computer Mains Universal Switchmode Multi-Voltage Power Supply

NEW PRODUCT

Replacement power supply for your laptop computer. Features high output current, short circuit protection, power LED indicator and high efficiency Switchmode operation. It also has universal input voltage. It will operate on 100-240VAC so it can be taken overseas. Output voltages are 15, 16, 18, 19, 20VDC @ 3.5A and 22,24VDC @ 2.9A regulated.

Cat. MP-3460 $129

Aura Cushion Interactor Deal

This cushion is designed to sit on a chair, for home theatre or computer games. Feel the extra realism, every punch and explosion. Loads of fun for kids and adults alike. See Jaycar Catalogue page 335 for full details.

Was $29.95 Save $10.00
Cat. XC-1005 Now $19.95

Dummy Mini Dome Camera

NEW PRODUCT

This dummy dome camera looks exactly like the real thing, at a fraction of the price. Make your business/home/office look like it's under surveillance.

Cat. LA-5317 $9.95

Sound Activated Baby Cot Light

This light is just the thing for anyone with a newborn baby, or child scared of the dark. The light can be sound activated. When your child starts crying at night, the light will automatically switch on, and stop you fumbling in the dark for a light switch when coming to their aid.

Cat. ST-3029 $19.95 NEW PRODUCT

6 Way Black Mains Board with Phone Filter

New stealth coloured filter power board. This mains filter board provides surge and spike protection for AV and Hi-Fi equipment. Phone sockets offer protection for your phone or modem.

Cat. MS-4037 $39.95

NEW PRODUCT

eTREX Handheld GPS

The GARMIN eTrex is an entry level unit for outdoors enthusiasts. It features easy operation, strong performance and value for money. All information is accessible via the 5 side mount buttons, on a well presented, backlit LCD screen. Housed in a rugged water resistant case, the eTrex will go anywhere. Ask at your local Jaycar store for full details.

CHECK THE GREAT PRICE

Cat. DC-1050 $349 NEW PRODUCT

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New Products - please check that they have arrived in stock

Please phone ahead and check that the new products you are after have arrived in your store before driving across town.

Wireless Home Alarm System

NEW PRODUCT

Wireless security systems are an attractive alternative to wired systems; especially for those who rent their home or who live where passing wires through wall cavities is not feasible. The system boasts the latest in wireless security technology. Includes Alarm panel, 2 PIR's, 1 Reed switch, wireless remote control, 240v plugpack and comprehensive manual. For more details see page 171, 2002 catalogue. Extra PIR's available.

Cat. LA-5460 $449.00

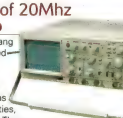
Samsung Digital Voice Recorder

This incredible digital voice recorder from SAMSUNG® will store up to 810 minutes (Yes! That's 13.5 hours) of voice quality audio in a neat & slim, hand-held unit. Four separate message groups are available and each group can have up to 100 messages. An integrated LCD shows the status of various functions. The recorder has a VOX function and variable microphone sensitivity for voice operated recording. Software is included to enable messages to be downloaded to a PC and e-mailed to friends or colleagues.

Normally $419 Save $40

Cat. XC-0280 $379

Keyring Alarm with Flashlight



This compact, lightweight personal alarm will emit an unbearable 120dB scream which is enough to scare off the most determined theif. It also has an inbuilt light to aid you through the night.

Cat. LA-5185 $11.95

Ex-Display Stock of 20Mhz Hung Chang Cro

Ex-display stocks of Hung Chang Cro's are in stores at a reduced price NOW! These fantastic CRO's are easy to read and operate, while still offering all the features expected. Such as dual channel, Quad trace abilities, 6" screen and high sensitivity. They are perfectly suited for professionals and hobbyists alike. Limited quantity available, please call your local store for availability. Not available from Techstore Mail Orders.

Normally $799 Save $100

Cat. QC-1908 $699 Quantity strictly limited.

Free Gifts with Anti-Static goot Soldering Station with Digital Display

Never before has this precision piece of equipment been offered as part of such a fantastic package. The Japanese made GOOT features excellent temperature stability and anti-static characteristics. With a temperature range of 200-488°C, the GOOT will suit just about every project for professionals and hobbyists alike. Offered with the package below, the GOOT is excellent value for money, and is backed with a one year warranty.

SPECIAL BONUS FOR AUGUST ONLY

With every GOOT Soldering Station purchase, we will give you a **FREE**:

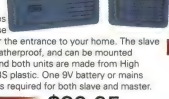
- Deluxe Tip Cleaner - TS-1510 $12.95
- A 1Kg Roll of 0.71mm Solder - NS-3002 $28.95
- A GOOT Desolder Braid - NS-3027 $4.95

THAT'S $46.85 VALUE ABSOLUTELY FREE!

Cat. TS-1440 $269.95

Wired Doorphone/Intercom

NEW PRODUCT



Opening your front door or gate without knowing who's on the other side can be a risky business, so it makes good sense to monitor the entrance to your home. The slave unit is weatherproof, and can be mounted outside, and both units are made from High Impact ABS plastic. One 9V battery or mains plugpack is required for both slave and master.

Cat. AI-5505 $39.95

Sparkplug Keyring LED Torches

Looks just like a sparkplug, but twist its body and its a powerful LED torch

White LED - ST3068

Blue LED - ST-3069

Normally $14.95ea Save $9.90

Cat. ST-3068
Cat. ST-3069

2 for $20

Can be different colours.

Machined Aircraft Grade Water Resistant Aluminium Torch

With push on/off switch. Requires 2 x AA batteries (Sold separately).

Normally $15.95 Save $3

Cat. ST-3054 $12.95

USB Mobile Phone Charger

NEW PRODUCT

Your mobile phone is dead and you don't have your charger? Simply plug your USB Telecharger® into your mobile phone and connect to your PC or laptop USB port to power or charge your mobile phone. Suits most Nokia, Ericsson and Motorola phones.

Cat. XC-4837 $24.95

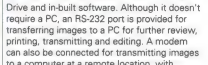
Refillable Piezo Pocket Torch

A lightweight, handy pocket torch ideal for camping, heating small objects, lighting fires in windy conditions etc!

Normally $19.95 Save $5.00

Cat. TS-1662 $14.95

Digital Video Recorder with 4 Channel Real-Time Display



The QC-3052 uses it's own 20GB Hard Disk Drive and in-built software. Although it doesn't require a PC, an RS-232 port is provided for transferring images to a PC for further review, printing, transmitting and editing. A modem can also be connected for transmitting images to a computer at a remote location, with network connections also provided if a PC is located in the same building. NTSC and PAL video outputs are provided to locally monitor video signals. We have made available on our website, the entire list of functions available to the QV-3052.

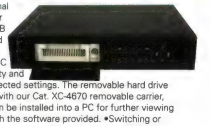
- Software-based motion detection recording
- LAN networking to a PC - max 10mbps
- 320 x 240 resolution, true colour recording
- Max 120fps single channel recording
- 19" Rack mounting kit supplied

Normally $3495 Save $500

Cat. QV-3052 $2995

4 Channel Digital Surveillance Video Recorder DVR

NEW PRODUCT



This Professional quality recorder features a 40GB removable hard drive, external triggering, NTSC or PAL capability and password protected settings. The removable hard drive is compatible with our Cat. XC-4670 removable carrier, so the drive can be installed into a PC for further viewing and editing with the software provided. •Switching or four-way split display. •352 x 288 Resolution.

- Compatible with any IDE Hard Disk up to 200GB.
- Dimensions: 420(W) x 87.9(H) x 318(D). Contact our sales staff for further details.

Cat. QV-3060 $1995

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Wireless Digital Rain Gauge with Thermometer

NEW PRODUCT

A combined rainfall meter and indoor thermometer, which requires no wiring or mains power. The rainfall collection well transmits data to the digital display. See Cat. Pg. 327

Cat. XC-0305 $119

Vibro Pen

Designed to alleviate aches and pains, this pen is in a class all by itself with its vibrating head. Simply press the head onto pressure points of the body for the desired effect. Instructions and pressure point chart included.

Cat. ST-3096 $24.95

Laser Pointer Pen with Mobile Phone Alert

Providing a more discrete way of answering your mobile in meetings, this pen features 4 LED's that flash when your mobile phone rings, a 1mw laser pointer is built into the top of the pen making it the ultimate accessory, and it can write also.

Cat. ST-3091 $24.95

Digital Rain Gauge

NEW PRODUCT

This meter shows two separate displays of measured rainfall, plus accrued data reading. Rainfall collector is connected via a 10 metre cable. Either display can be reset any time. See Cat. Pg. 327.

Cat. XC-0300 $79.95

PC Supercooler With Temp Display

NEW PRODUCT

Features a two channel thermometer which can alarm above preset temperatures, twin cooling fans, and two temperature probes which can attach to any component. See Cat. P40

Cat. XC-5025 $89.95

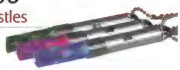
Heavy Duty Jumper Lead Kit

10 leads with alligator clips on each. 5 colours. Lead length approx. 400mm. **Limit 2 Per Customer.**

Normally $8.95 Save $3.00

Cat. WC-6020 $5.95

LED Illuminated Whistles



Translucent barrel glows with light and can be selected to flash at the touch of a button.
Three Colours Available
Red: Cat. ST-3093 Green: Cat. ST-3094 Blue: Cat. ST-3095

Were $11.95 Save $4 All colours now $7.95ea

Power Jump Skipping Rope

Keep track of your exercise with our Hi-Tech skipping rope. Great for cardio-vascular fitness, this skipping rope calculates energy consumption and number of jumps. Also includes timer alarm from 1 to 60 minutes.

Was $24.95 Save $10

Cat. YS-5550 NOW $14.95

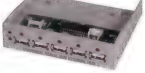
Bench Laboratory Magnifier Lamp

115mm diameter lens provides 3 dioptre magnification, and the arm can be positioned on almost any angle. 22 Watt circular fluoro light housed under a clear protective screen. Convenient on/off switch positioned on a quality ABS head.

Was $149 Save $20

Cat. QM-3522 NOW $129

Five Port Internal USB Hub



This USB hub mounts in a spare 3.5" drive bay (or 5.25" bay using the supplied adaptor) to give you a convenient 5-port hub on the front of your machine. The hub features four or five downstream ports with individual port over current detection and protection. Compatible with PC's and Mac's.

Cat. XC-4825 $59.95

11PC Cellular Phone Toolkit

This kit includes essential tools to access the internals of mobile phones. Quality Chrome Vanadium presented in a felt lined case. See Cat. Pg 208.

Was $29.95 Save $5

Cat. TD-2024 $24.95

Gold RCA Socket Bargains

HIGH QUALITY INSULATED
Requires a 9.5mm diameter panel hole.
Red PS-0221
Black PS-0220

1+ $1ea 10+ $0.50ea

Plug Adaptor 605 Type

Australian plug to RJ12 6p/4C US socket.
Limited quantity.

Normally sell for around $5.95

Cat. YT-6053 Only $3.95

Two Station Wireless Intercom

Great for communicating around your home, out to your garage or even down to the back shed. The units work on an FM wireless principle and transmit through the electrical cable already laid in your house. Additional units can be added.

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Cat. AI-5500 NOW $64.95

3.2mm Mini Female Spade

INSULATED - PKT 20
Similar to our phone type spade connectors PT-4520. Cable enry 3.6mm, spade width 3.2mm
Packet of 20

Cat. PT-4532 $2.50

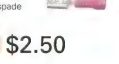
Clam Shell Style CD Cases

Multicoloured, new style, flexible and see through. Two of each colour - blue, red, violet, yellow and green
Packet of 10

NEW

Cat. AR-1482 $3.95

DVD Cases

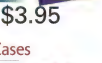


Virtually unbreakable, with clear plastic outer sleeve for cover page & booklet retainer clips. Black - 136x190x14mm.
Packet of 3

NEW

Cat. AR-1490 $4.95

DVD Jewel Cases



Multicoloured and see through. One of each colour - blue, green, purple, red, yellow, clear and black.
Packet of 7

NEW

Cat. AR-1481 $3.95

12VDC 1A Switchmode Plugpack

Regulated output voltage. Short circuit and overload protection. Supplied with 7 plugs.

Was $32.95 Save $5

Cat. MP-3137

NOW $27.95

OVERNIGHT DELIVERY AVAILABLE*

1800 022 888

Can't make it to one of our stores then let our store come to you!

www.jaycar.com.au

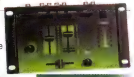
500WRMS Class D Subwoofer Amplifier

State of the art 'Switching' technology makes this 'Class D' amplifier perfect for any home installation. See page 233 of the Jaycar Catalogue for full details.

Normally $799 Save $200

Cat. AA-0510 $599

2-Input Stereo DJ / Multimedia Audio Mixer



This 2-channel stereo mixer accepts both line and phono level inputs. Features LED level indicators, separate channel level faders, cross fader, cue level and mic level controls. Removable rack mounting brackets are included. 12VAC plugpack included. See Jaycar Catalogue. Page 241

NEW PRODUCT

Cat. AM-4205 $99

5-Input Stereo DJ Mixer

Designed for DJ use, this stereo mixer features a removable cross-fade slide control, LED VU meters, dedicated gain controls for each channel (including the master output) and cue level and mixing controls. The mixer accepts both phono and line level inputs and features mains power, line level outputs for recording to a DAT or tape deck, etc. See Cat. P241.

Cat. AM-4210 $169

Sensational Koss Headphone Deal

Normally KOSS (US Made) Headphones are very expensive. Not in this case, as we have purchased the remainder of a production run for Ford Motor Co. USA. They are lightweight with adjustable headband. Note that there are two headphones and two 6.5/3.5mm adaptors (PA358B) in the deal. Excellent value for money.

Was $39.95 Save $5

Cat. AA-2040 $34.95

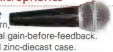
Fantastic Savings on our Professional Microphones

Supercardioid Professional Microphone

This dynamic microphone has a cardioid polar pattern which reduces background noise. Offers exceptional gain-before-feedback. Supplied with a 5m cable to 6.5mm metal plug, and zinc-diecast case.

Cat. AM-4097 WAS $95.95 **NOW $75.95** SAVE $20

Unidirectional Balanced Professional Vocal Dynamic Microphone



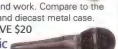
A top quality balanced mic suitable for singing or band work. Compare to the Shure SM58! Supplied with 6m, 3pin Cannon lead and diecast metal case.

Cat. AM-4098 WAS $89.95 **NOW $69.95** SAVE $20

Unidirectional Professional Dynamic Mic

This low impedance microphone looks great with its all black appearance and offers excellent reproduction of voice and music. Suitable for PA and Recording use. Supplied with 6m cable to 6.5mm plug and zinc-diecast case. **Cat. AM-4094** WAS $59.95 **NOW $44.95** SAVE $15

Dynamic Professional Vocal Microphone



Featuring a High Strength ABS Plastic handle, built in On/Off Switch, and a 5m cable to 6.5mm plug, this mic makes an ideal Karaoke mic. **Cat. AM-4084** WAS $35.95 **NOW $25.95** SAVE $10

Super Speaker Sale

Don't miss out on these great savings for August only. See Jaycar catalogue page 221–227 for full details.

1" Screened Dome Tweeter
Was $20.95 Save $4
Cat. CT-2006 $16.95

3" Magnetically Screened Woofer
Was $27.95 Save $4
Cat. CW-2103 $23.95

4" Magnetically Screened Woofer
Was $32.95 Save $6
Cat. CW-2104 $26.95

5" Magnetically Screened Woofer
Was $49.95 Save $10
Cat. CW-2102 $39.95

6.5" Magnetically Screened Woofer
Was $78.95 Save $14
Cat. CW-2107 $64.95

1" Dome Tweeter
Was $19.95 Save $4
Cat. CT-2008 $15.95

6.5" Paper Cone Woofer
Was $23.50 Save $4.55
Cat. CW-2105 $18.95

8" Paper Cone Woofer
Was $29.95 Save $5
Cat. CW-2110 $24.95

10" Paper Cone Woofer
Was $35.95 Save $6
Cat. CW-2119 $29.95

12" Paper Cone Woofer
Was $49.95 Save $10
Cat. CW-2125 $39.95

CD-R Labelling Kit

Make Professional quality CD labels with the comprehensive design software and labelling machine. Kit includes CD labelling machine, pack of 50 labels and CD ROM design software.

Cat. XC-4784 $49.95

CD-R Label A4 Refill Pack - Pk.50 labels

Cat. XC-4785 $19.95

Volt, Temp, Clock Display for Cars

NEW PRODUCT

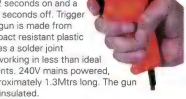
This stylish display features a cool EL backlit LCD, battery voltage, in/outside temp. time and date. See cat P328 for details.

Cat. XC-0116 $39.95

Stock up and Save! CDR/RW and DVDR/RW Reduced

Singles	Was	Now	10+	Save	Cat.
PHILIPS CD-R GOLD	$1.95ea	$1.70ea	$1.65ea	$0.25	XC-4711
TDK 80 MIN AUDIO	$1.95ea	$1.80ea	$1.65ea	$0.15	XC-4706
MITSUI CD-R GOLD	$1.65ea	$0.99ea	$0.90ea	$0.66	XC-4709
LASER 80 MIN AUDIO	$1.65ea	$1.10ea	$0.95ea	$0.55	XC-4705
CD-RW	**Was**	**Now**	**10+**	**Save**	**Cat.**
AVALON 650MB/74MIN	$2.50ea	$1.85ea	$1.65ea	$0.65	XC-4720
LASER 700MB/80MIN	$3.95ea	$2.95ea	$2.60ea	$1.00	XC-4723
DVD	**Was**	**Now**	**10+**	**Save**	**Cat.**
LASER DVD-R	$8.95ea	$7.95ea	$6.95ea	$1.00	XC-4721
LASER DVD-RW	$13.95ea	$12.95ea	$11.35ea	$1.00	XC-4722
CD-R Packs	**Was**	**Now**		**Save**	**Cat.**
VALUE PACK OF 15	$11.95ea	$10.95ea		$1.00	XC-4708
LASER 80MIN PK 20	$19.95ea	$13.95ea		$6.00	XC-4710
LASER 80MIN PK 50	$39.95ea	$28.95ea		$11.00	XC-4718

100W Soldering Gun with Pilot Light



The tip can reach full temperature in seconds - great for fast jobs - with a maximum of 12 seconds on and a minimum of 48 seconds off. Trigger controlled, the gun is made from lightweight, impact resistant plastic and also features a solder joint illuminator for working in less than ideal light environments. 240V mains powered, mains lead approximately 1.3Mtrs long. The gun itself is double insulated.

Was $29.95 Save $5

Cat. TS-1425 $24.95

Save on Rechargeable Ni-Mh Batteries - August Only

		Normally	Buy 4+	Buy 10+	Buy 20+
AAA 650mAh Nipple	Cat. SB-2444	**$3.59**	**$3.15ea**	**$2.75ea**	**$2.35ea**
AAA 650mAh Tags	Cat. SB-2446	**$3.78**	**$3.30ea**	**$2.95ea**	**$2.55ea**
AA 1650mAh Nipple	Cat. SB-1700	**$4.50**	**$3.95ea**	**$3.60ea**	**$3.20ea**
AA 1650mAh Tags	Cat. SB-1702	**$4.75**	**$4.15ea**	**$3.75ea**	**$3.35ea**
AA 1800mAh Nipple	Cat. SB-1705	**$5.95**	**$5.25ea**	**$4.75ea**	**$4.35ea**
Sub C 2700mAh Tags	Cat. SB-2447	**$8.95**	**$7.95ea**	**$7.45ea**	**$6.95ea**
C 4500mAh Nipple	Cat. SB-2429	**$14.95**	**$13.95ea**	**$11.70ea**	**$10.95ea**
D 8000mAh Nipple	Cat. SB-2449	**$24.90**	**$22.95ea**	**$21.95ea**	**$20.95ea**
9V (8.4V) 200Ah	Cat. SB-2467	**$14.95**	**Aug. Only $12.95ea**	**Buy 10+ $10.95ea**	
AA 1000mAh Nipple	Cat. SB-2455	**$3.35**	**$2.95ea**	**$2.60ea**	**$2.30ea**
AA 1000mAh Tags	Cat. SB-2457	**$3.59**	**$3.15ea**	**$2.75ea**	**$2.45ea**

Universal Ni-Cad/Ni-Mh Battery Charger with Tester and Discharger

This unit charges AAA, AA, C, D, and 9V batteries. LED indicator lights, recharges groups or singles.

Normally $28.95 Save $9

Cat. MB-3505 **$19.95**

Dual Mains Phone Protection

Protect mains appliances and phone lines from voltage spikes and short circuits.

Normally $29.95 Save $5

Cat. MS-4028 **$24.95**

4/5 A 1800mAH Ni-Mh Battery

NEW PRODUCT

Solder Tags
Size 43(H) x 17(Dia)mm

Cat. SB-1718 **$8.95ea**

Crazy Inverter August!

Don't miss out on our Inverter bargains for August only
All Inverters below are; Input: 12VDC, Output: 230VAC
Electrically isolated for safety. See Catalogue Page 136 for full details.

140W (450W Surge)
Normally $109.50 Save $10
Cat. MI-5060 **$99.50**

300W (900W Surge)
Normally $159.50 Save $20.
Cat. MI-5062 **$139.50**

600W (1500W Surge)
Normally $299.50 Save $40
Cat. MI-5066 **$259**

1000W (2400W Surge)
Normally $529 Save $60
Cat. MI-5070 **$469**

Scoop Purchase on Amorphus Type Solar Panels

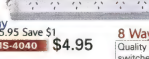
12V 2 Watt.
Size:
162 x 315mm.
Only 150
Available.
Normally $39.95

Save $10

Cat. ZM-9025 **$29.95**

Mains Power Boards

Both have resettable overload protection and a one metre lead. Maximum load is 2400Watts.



4 Way
Was $5.95 Save $1
Cat. MS-4040 **$4.95**

6 Way
Was $7.95 Save $1
Cat. MS-4045 **$6.95**

8 Way Colour Dil Switches

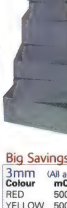
NEW PRODUCT

Quality English manufactured DIL switches all have different coloured actuators and flux wash stickers.

Cat. SM-1025 **$2.25ea**
10+ $1.95 25+ $1.80

20% Off Sealed High Impact ABS Boxes

High impact ABS in dark grey colour. Includes a tongue groove sealing system with neoprene gasket IP65 rating



	L x W x H(mm)	Was	Now	Save
Cat. HB-6120	64 x 58 x 35	$5.90	$4.72	$1.18
Cat. HB-6122	115 x 65 x 40	$7.25	$5.80	$1.45
Cat. HB-6124	115 x 65 x 55	$9.65	$7.72	$1.93
Cat. HB-6126	115 x 90 x 55	$11.75	$9.40	$2.35
Cat. HB-6128	171 x 121 x 55	$19.00	$15.20	$3.80
Cat. HB-6129	171 x 121 x 80	$20.50	$16.40	$4.10
Cat. HB-6130	222 x 146 x 55	$24.75	$19.80	$4.95
Cat. HB-6132	222 x 146 x 75	$25.75	$20.60	$1.15
Cat. HB-6134	240 x 158 x 90	$35.95	$28.76	$7.19

Shortwave Radio - Auto Tuning

This radio will scan until it finds a station and then lock onto it. Frequency shown on a large LCD, and will store up to 6 presets per band.
See Cat P331 for details.
Manual Tuning Version **Cat. AR-1798** **$39.95**

Cat. AR-1797 **$129.95** **NEW PRODUCT**

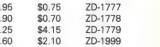
Save $$$ on Small Cable Rolls

OFC Monitor Cable 30m Roll **Cat. WB-1736**
Was $89.95 **NOW$69.95** Save $20

Gas Injected Foam 75Ω
Coaxial 30 metre Roll **Cat. WB-2005**
WAS $26.95 **NOW $16.95** Save $10

4 Core Alarm Cable 30 metre Roll **Cat. WB-1591**
Was $18.95 **NOW $12.95** Save $6

Big Savings on High Brightness LED's



3mm (All are waterclear)

Colour	mCd	Normally	1+	10+	25+	Cat.
RED	5000	$2.10	$1.60	$1.40	$1.10	ZD-1757
YELLOW	5000	$2.10	$1.60	$1.40	$1.10	ZD-1758
GREEN	3500	$3.95	$3.45	$3.05	$2.30	ZD-1991
BLUE	4000	$7.80	$6.80	$5.95	$4.75	ZD-1759

5mm (All are waterclear)

Colour	mCd	Normally	1+	10+	25+	Cat.
RED	6500	$1.60	$1.10	$0.95	$0.75	ZD-1777
YELLOW	5000	$1.25	$1.00	$0.90	$0.70	ZD-1778
GREEN	6000	$7.80	$5.95	$5.25	$4.15	ZD-1779
BLUE	3000	$3.50	$3.00	$2.60	$2.10	ZD-1999
WHITE	7000	$3.95	$3.45	$3.05	$2.30	ZD-1997

Save on 3 Pin XLR Cannon Type Connectors

See Catalogue page 60 for full details.

		Was	August	Buy10	Buy 50
3 Pin Line Male	Cat. PP-1012	$3.95	$2.95	$2.60	$2.30
3 Pin Line Female	Cat. PS-1015	$3.95	$2.95	$2.60	$2.30
3 Pin Chassis Male	Cat. PP-1010	$3.95	$2.95	$2.60	$2.30
3 Pin Chassis Female	Cat. PS-1014	$5.00	$3.95	$3.45	$3.15

High Brightness 5mm "White" LED Bargain

We have a limited quantity of a "white" waterclear 5mm LED. We would call the light output, off white - with a very very slight green tinge. These are in our 2001 catalogue at $4.45 each.
Specs: Mcd 1500, current 20mA, nom voltage 3.5v.

Only $1ea or Buy 10+ 90¢ ea

Cat. ZD-1786

12VDC/20A 250VAC/10A SPST Switch

This toggle is ideal for car amps, driving lights, boating or any high current 12VDC switching application. Suits missile switch cover on the right.

Cat. ST-0579 **$4.95**

Military Style Missile Switch Cover

Switch cover featuring a red, heavy duty hinged, spring return protective cover. Fits any toggle switch with a 12mm mounting hole.

ST-0578 **$12.95**

Techstore Mail Order Specials

Limited stocks. Not available from regular Jaycar stores.

Power Saver Inverters

We have a limited quantity of ex-repaired inverters from our 2000 Catalogue. Now is the time to make some serious savings. All units have a 3 month warranty.

200W 12 to 230V
WAS $119.50 NOW $69 SAVE $50.50
Cat. MI-5032 36 Only

200W 24 to 230V
WAS $119.50 NOW $69 SAVE $50.50
Cat. MI-5033 4 Only

350W 12 to 230V
WAS $179 NOW $99.50 SAVE $79.50
Cat. MI-5035 6 Only

550W 12 to 230V
WAS $269 NOW $149.50 SAVE $119.50
Cat. MI-5040 7 Only

920W 12 to 230V
WAS $499 NOW $299 SAVE $200
Cat. MI-5045 8 Only

350W Sinewave 12 to 230V
WAS $349 NOW $229 SAVE $120
Cat. MI-5050 19 Only

750W Sinewave 12 to 230V
WAS $769 NOW $499
SAVE $270 10 Only
Cat. MI-5055

Cat. MI-5032

Cat. MI-5035

Cat. MI-5055

Ex-Repair Equator Car Alarm

Features code hopping, engine immobiliser, central locking control, LED warning and shock sensor. Two styles of remotes are available, though Jaycar reserves the right to supply what is left in stock.
Cat. LA-8902
Type A 25 Only Type B 21 Only
WAS $189 NOW $119 SAVE $70

Type A

Type B

Ex-Repaired and Slightly Soiled Stock

All in good working order with 3 months warranty.

CCD 4-Way Auto Switcher
Switches between cameras or can stay on one.
WAS $149.50 NOW $89 SAVE $60.50
Cat. QC-3480 19 Only

Cat. QC-3480

240W Active Subwoofer Amp with Remote 240W into 4Ω.
WAS $329 NOW $229 SAVE $100
Cat. AA-0506 2 Only
Returned but in new Condition:

Cat. AA-0505

240W Active Subwoofer Amp with Remote 240W into 4Ω.
WAS $329 NOW $259 SAVE $70
Cat. AA-0506 9 Only

200W Active Subwoofer Amp with Remote 200W into 4Ω.
WAS $319 NOW $219 SAVE $100
Cat. AA-0505 14 Only

Cat. AA-0502

65W Active Subwoofer Amp 65W into 4Ω.
WAS $199 NOW $109 SAVE $90
Cat. AA-0502 3 Only

Speaker Cable

Heavy Duty Speaker Cable 30m Roll 24/0.20mm.
WAS $19.50 NOW $10 SAVE $9.50
Cat. WB-1705 64 Rolls available

Extra Heavy Duty Fig. 8 100m Roll 79/0.20mm.
WAS $187.95 NOW $85 SAVE $102.95
Cat. WB-1711 43 Rolls available plus $5 extra P&P

These products are only available from Techstore & Mail Orders. Call them on 1800 022 888 or visit our website
www.jaycar.com.au

PS/2 Optical Mouse

Do away with the traditional clumsy ball, and replace it with sophisticated, trouble free optical technology. Software supplied. Compatible with Windows 95, 98, 2000 and NT.

Normally $64.95 Save $15
Cat. XM-5125 $49.95

69 Channel UHF Handheld Transciever

These transceivers can provide up to 1km range line of sight. Its lightweight and compact construction make it the perfect companion. Supplied with belt-clip and instructions.

Cat. DC-1020 NEW PRODUCT

Only $69.95ea

40 Channel UHF Communicator

This high quality pocket transceiver works on the UHF band and gives an open field range of up to 5km and an inner city range of up to 1km with just 0.5W output, and even greater range with its repeater function. A hands free VOX kit and battery-charger are available.

Hands Free VOX Kit
Cat. DC-1012 $14.95
Mains Charger
Cat. DC-1014 $14.95
Cat. DC-1010 $79.95

Mini Indoor/Outdoor Thermo with Clock

This handy little thermometer monitors the inside and outside temperature in °C and displays either one at the press of a button. Outside sensor has a 3 metre cable that is detachable. Battery included.

Was $19.95 Save $5
Cat. QM-6324 Now $14.95

LCD 'Vernier' Type Engineers Caliper

Made from Surgical Grade Stainless Steel, and featuring a 5 digit LCD, this caliper is a precision piece of equipment. Supplied with foam inserted storage case. See Cat. page 209.

Was $79.95 Save $15
Cat. TD-2082 Now $64.95

Mini Strobe Light

Uses a Xenon Flash Tube and has variable flash rate up to 10Hz. Supplied with adjustable mounting bracket and case. 240V Operation

Was $38.95 Save $9
Cat. SL-2990 Now $29.95

4 Channel Surveillance Video Capture Card with Sound

The card incorporates high speed real time compression and digital motion detection. Features include scheduled recording, alarm alert & pre-alarm recording. In addition, the surveillance images can be accessed remotely via a LAN, WAN or even the Internet. It can be set to alert a remote PC and send live video of the alarm camera. For more see catalogue page 279.

Was $849 Save $50
Cat. QV-3055 $799

16 Channel Full Duplex Surveillance Multiplexer

This professional unit is designed to manage surveillance of up to 16 separate locations simultaneously. Ideal for medium to large sized offices and shops. *May be store display model.

Was $1799 Save $300
Cat. QC-3365 Now $1,499

Outdoor UHF Hi/Lo/VHF Triplexer

Mounts directly onto the TV mast. Can be used as a triplexer for UHF Hi/Lo/VHF input or a diplexer for UHF/VHF and have one cable from the antenna to yor home. Half the price!!!

Cat. LT-3013 $7.50

Scoop Purchase on High Quality Headphones

Features a 5metre extra long lead with individual volume control, and a 3.5mm gold plug. The headband is lightweight, fully adjustable and has cushioned ear pads. Excellent value at only $8.95ea

NEW PRODUCT
Cat. AA-2001 $8.95ea

Supplied with volume control.

OVERNIGHT DELIVERY AVAILABLE*

Can't make it to one of our stores then let our store come to you!

1800 022 888

www.jaycar.com.au

Wall Plate and Inserts for A/V Outlets

These are designed to provide custom audio/video outlets through your home. A/V connectors only fit one way in the plate so you have a front and rear connection. Fits standard mains points. See catalogue page 54 for details.

Wall Plates NEW PRODUCT

Blank Plate **Cat. PS-0480**
1 Hole Insert **Cat. PS-0481**
2 Hole Insert **Cat. PS-0482**
3 Hole Insert **Cat. PS-0483**
4 Hole Insert **Cat. PS-0484**
6 Hole Insert **Cat. PS-0485**
8 Hole Insert **Cat. PS-0486**

$1.75ea

Gold Binding Post/Binding Post

Will accept banana plug.
RED Cat. PS-0490 $2.50ea
BLACK Cat. PS-0491 $2.50ea

Gold Banana Socket/Binding Post

RED Cat. PS-0492 $2.25ea
BLACK Cat. PS-0493 $2.25ea

Gold RCA Socket/F-61 Socket

Cat. PS-0494 $1.65ea

Gold RCA Socket

Solder connection rear.
RED Cat. PS-0495 $1.95ea
BLACK Cat. PS-0496 $1.95ea

Gold F-61 Socket/Socket

Cat. PS-0498 $1.65ea

CCD Professional Aluminium External Camera Housing with Inbuilt 24V Heater

This weatherproof enclosure is ideal for adapting our Professional range of CCD video cameras for commercial outdoor use. It features an internal heater to stop the housing humidifying, which can cause clouding of the viewing glass and lens.

NEW PRODUCT

Cat. QC-3331 $69.95

High Capacity Rechargeable Torch

This beauty features a Panasonic 4.2Ah 6V rechargable SLA battery and high brightness Krypton bulb. The torch has a concentrated focus beam, is water resistant and includes a mains charger.

Normally $39.95 Save $10
Cat. ST-3082 $29.95

Keyring Super Bright White LED Torch

This robust aluminium torch features 'O' ring seals for good water resistance and a single super-bright white LED, for bright, long lasting light. Features rubber grips, spring loaded carabineer key ring, and batteries included.

Normally $19.95 Save $5
Cat. ST-3072 $14.95

Waterproof Torch/Strobe Emergency Beacon

Emergency beacons are essential items for boating enthusiasts, yachties, skiers and hikers. A small twist of either end of the device activates the strobe or torch. The beacon is waterproof, tested to a depth of 100metres.

Normally $46.95 Save $10
Cat. ST-3028 $36.95

CCTV Camera Brackets NEW PRODUCTS

Small Professional CCD Camera Mounting Bracket

This small yet strong bracket allows any of our Professional Cameras to be easily mounted to any suitable surface. **Cat. QC-3332** $8.95

Ceiling Grid Mounting Version

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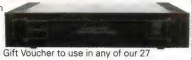

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Cat. KA-1760 $599

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Ref Silicon Chip June 2002
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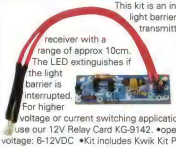

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Refer SC Nov. 2001
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Refer SC April 2001
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Ref: SC Nov 2001
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SERVICEMAN'S LOG

When two faults are better than one

Two identical sets seldom turn up on the bench at the same time but when they do, they can be mutually beneficial when it comes to trouble-shooting. Voltages and CRO patterns can be compared and components swapped, which makes it easier to track down faults.

I don't normally see many JVC TV sets, a fact that I attribute more to their excellent reliability rather than them not being the market leaders. In fact, I feel that their circuitry is somewhat more complex than in other sets but they are certainly well built.

Anyway, I was suddenly privileged to have not just one JVC set in for repair but two of the same model. They were both 1989 68cm AV-S290AUT (BY-I chassis) stereo sets. I don't really want to dwell on how I became involved in fixing these but it went something on the lines of the old mates act and redeeming outstanding favours (I seem to get into far too many of these situations!).

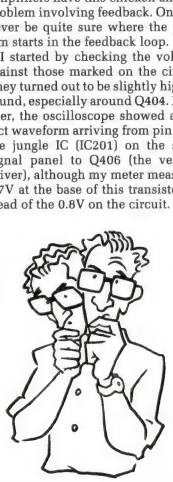
The first set (Set No.1) arrived in my workshop six months ago with the complaint that it was dead. It wasn't really but the main 115V HT rail was extremely low and replacing capacitors C951 and C952 (220µF 160V) fixed the problem and I thought the customer had gone away happy.

Obviously I was wrong and had done something to offend because the set recently resurfaced at my mate's opposition workshop which isn't all that far away. And my mate, after having had a tinker, decided to call in a favour I owed him.

The fault was described as retrace lines and vertical top foldover. At my suggestion, the workshop's technician, who I might add is a very capable lad, had changed all the electrolytic capacitors in the vertical timebase but to no avail. I don't know what other "tinkering" might have taken place by the time the set finally came to me but I was now on my own.

I hate problems such as these and I am grateful that I do not do many audio amplifier repairs, as they are very similar to vertical output stages. Amplifiers have this chicken and egg problem involving feedback. One can never be quite sure where the problem starts in the feedback loop.

I started by checking the voltages against those marked on the circuit. They turned out to be slightly high all round, especially around Q404. However, the oscilloscope showed a perfect waveform arriving from pin 13 of the jungle IC (IC201) on the small signal panel to Q406 (the vertical driver), although my meter measured 0.7V at the base of this transistor instead of the 0.8V on the circuit.



The main question was whether this 0.1V was critical, because the waveform became distorted on the retrace part of the waveform, at the collector of Q406. Was the transistor being forward biased adequately? The distortion showed up as a small lump on the retrace pulse.

The circuit is conventional enough, with Q406 driving two transistors, Q401 and Q402, in push-pull. The unusual part of the circuit was a signal take-off between the two outputs via two zener diodes – D403 (MA4200, 20V) and D402 (MA4270, 27V). This goes to "vertical drive" transistor Q403 which in turn drives Q405. Q405 then provides vertical blanking pulses to Q404, which are fed back to Q401.

There are two errors in the circuit diagram. Q401 (2SD1271A) is an NPN transistor and not PNP as marked, with the collector going to the collector of Q404. There is also an additional diode (D408) between Q403 and Q405. And its anode is connected to R410, not R402.

Some in-circuit resistance checks here provided no further clues and I was unsure as to what to do next. And then, as luck would have it, the identical set (Set No.2) arrived – only this one was very sick. It was severely rusted and corroded but I decided to try to repair it in the hope that this would help to fix set No.1.

Unfortunately, after spending an hour on or so it, I realised the problems were too extensive to make a complete repair worthwhile. The set was dead, with no picture, no sound, no vertical timebase, no remote control and no teletext! And at least one component was overheating.

I fixed the power supply, patched up the overheated horizontal output transformer and made the vertical timebase work by replacing R552 (5.1Ω 3W). Fixing the picture was much harder but the fault turned out to be diode D321 in the base circuit of Q203 and Q306.

AT MY SUGGESTION, THE WORKSHOP'S TECHNICIAN, WHO IS A VERY CAPABLE LAD, CHANGED ALL THE ELECTROLYTIC CAPACITORS

The remote control failure was due to IC004 TC4049BF, a surface-mounted inverter on the "S Select Module". I didn't fix that but I did replace four surface mounted electros – C010, C013, C016 & C017 – which affected the set's memory. I also let the teletext fault go but suspected Q104 on the module. The sound fault involved IC651 (TA7630P).

The same fault

Having done the basics to achieve a picture, it was disappointing to find that this set also had the same fault as the first set – retrace lines and foldover! Despite this, I still felt that I could use this second set to track down the problem.

I took some voltage readings and quickly found that although the second set displayed exactly the same symptoms, the cause was entirely different. First, R409 (1.5kΩ) was getting hot and the voltages around Q404 were low this time.

I replaced C403 (33μF), which decouples the other side of R409 (this resistor connects to the 115V HT rail), but it made no difference. It looked as though Q404 was being switched on too hard by Q403, which had voltage on its base. Shorting it to chassis reduced the strain immediately. The voltages across the output transistors were correct, so the obvious suspects were the zener diodes D402 and D403. Replacing these immediately fixed the fault.

This was important, because I now had a reference set that I could use to tackle set No.1. And naturally, I hoped that the fault would turn out to be the same. Unfortunately, when I replaced these zeners, it made no difference.

The resistance of the vertical deflection coils was the same (25.4Ω) on both Panasonic tubes. Nevertheless, I swapped the chassis over to confirm that the coils were OK. I was also able to swap the small signal panels to confirm that the vertical drive was correct for both. I had already checked that the voltage rail (supplied via D404, R522 and D552 from pin 7 of the horizontal output transformer) was correct at 39.8V (nominally 41V) and I had also checked that R552 (4.7Ω) was OK.

Items Covered This Month

- JVC AV-S290AUT (BY-I chassis) stereo TV set
- Teac CT-M761ST 76cm TV set.

Naturally, I was still confident that I could quickly solve the problem with this simple 6-transistor circuit. It wasn't to be – over two hours later, after I had swapped every transistor and diode with set No.2 and checked almost all the resistors, I still hadn't found the fault. And there wasn't much left to change.

At this stage, I had a TV set with a complete new set of electros, transistors and diodes in the faulty circuit section. What's more, the supplies were correct and the waveform was fine going in. However, it was incorrect after the driver transistor and transistors Q403, Q404 and Q405 were not being switched on because of this distorted waveform. In fact, set No.2 showed that the retrace pulses should be very tall and thin whereas on set No.1, they were small and fat with a little lump on them.

I spent the next half hour checking all the possible ways this pulse could be attenuated so much, particularly concentrating on small capacitors like C404, C405, C409 and C410 but got nowhere. In the end, I was about to abandon the whole sorry mess and was contemplating whether to just swap the good parts and make one set out of the two.

And then it struck me – one thing I hadn't done was to check all those electros that had been replaced by the other technician. I knew he was conscientious and capable, so I didn't feel he was likely to have made a mistake. But now, having run out of all other ideas, I decided to go over his work.

He had in fact replaced over half a dozen capacitors but only five involved this part of the circuit – C401, C402, C403, C408 & C552. I decided to change them, as you can get faulty new parts occasionally. Replacing C401 made no difference but when I came to C402. I noticed that a 47μF capacitor had been substituted for the original 2.2μF (100V) unit. That's a huge difference – about 20 times bigger.

Fitting the correct capacitor value fixed the fault completely!

Well, the moral of this story really

doesn't need reiterating as it hurts! I have no excuses. The sad part is that, in all the mess, the exact cause of the original fault was never found – it was fixed somewhere along the track when one of the other parts was changed.

So overall, it was an unsatisfactory end even though the set was fixed. And at least I got to keep set No.2 which can now be used as a source of spare parts for other similar sets – always assuming more come in.

An intermittent Teac

My next job was an equally difficult one. I was asked by the wife of one of my mates to fix their TV set. The only problem at first glance was that it was a 76cm job and weighed a few tonnes. But it was worse than that – it had an intermittent fault which meant that it really should be tackled on the workshop bench.

Unfortunately for me, my friend (an ex-technician who saw the light and made a successful career change some years ago) was overseas on business. So there was no way of moving this set to the workshop.

The set was a 1996 Chinese built Teac CT-M761ST and it had a weird intermittent video fault that varied the colour, brightness, contrast and definition. Being intermittent, it couldn't be made to perform to order and though I did see the fault in action, I really had no idea where to start.

However, after careful consideration, I decided on a strategy of replacing all the electros in the power supply and those on the 210V rail to the video output stages on the CRT board. Hopefully, this would cover enough likely suspects to catch the elusive fault. And so, one clear afternoon, I called around with a service manual and the five electros I intended to replace.

After removing about 50 screws, I took the back off and found the chassis moved out with the release of four more screws – but where could I put it? There is no service position – if I needed to do any work underneath, I would have to hold the chassis up with one hand and solder with the other. But how does one unsolder us-

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ing solderwick or a solder sucker without a free hand?

Anyway, I eventually managed to replace the five capacitors – C7114, C717, C735, C713 & C616 – and switched the set on. Everything came on correctly and all was looking fine, so I switched the set to standby with the remote control and replaced the back.

However, when I switched it on again, there was no picture. I assumed that I must have done something silly putting the back on, like tearing a lead out of its socket or something. I removed the back and checked everything but the set just wouldn't cooperate. I could hear a varying "rustling" sound coming out of the power supply, the audio was fine, there was EHT and the CRT filaments were lit – but there was no picture!

Clearly, this was not a problem that I could solve on the spot. Apart from the humiliation of looking totally stupid in front of my mate's wife, I would be behind schedule with my remaining jobs for the afternoon if I persisted. The only thing I could do was take the chassis back to the workshop.

Back on the bench, I examined it carefully. There were a few doubtful joints but nothing significant. The new fault had to be due to something I had done, as it wasn't there before – unless some really unlucky coincidence had occurred.

I checked the polarity and values of the electrolytic capacitors I had replaced. They all had higher voltage ratings and lower leakage characteristics than the originals. Perhaps one was faulty?

Another five new capacitors was a small price to pay to solve the problem and it was easy to replace them again. I also examined a few other electros on the main HT rail – C719, C720 & C615 – but all were fine.

Back at the house, I reinstalled the chassis and switched on only to find that the fault was still there. I measured the main 125V HT rail, which I expected to be low (it should be 122V precisely). To my surprise, it was high and varying even higher! There was nothing for it but to take the chassis back to the workshop; this was too hard to tackle in the home.

No messing about

This time, I wasn't messing about (not that I was before). First, I replaced IC701 (TDA4601), the power supply controller. I then shorted the base and emitter of horizontal output transistor Q601 and hung a 100W globe between its collector and chassis.

Next, I reconnected the power and monitored the 122V rail. It started OK but began to rise fairly quickly. I measured the voltage out of the bridge rectifier to be a healthy 330V and changed C726, the main reservoir capacitor, just in case.

I then checked the voltages on all nine pins of IC701 and they were close to those marked on the circuit, the

exception being pin 5 ("V" Protect) which I measured at 7.0V (it should be 8.2V). Another thing I noticed was that the rustling sound became worse with the meter on pin 3 (error feedback). The voltage here was 2.1V which was close enough to the 2.0V specified.

Ironically, I am very familiar with this circuit – it is an extremely popular design used in many brands of TV sets. The one I have dealt with the most is the Goldstar PC-04X chassis, so I decided to compare notes with that circuit.

The Goldstar has pin 5 at 7.2V and the most common fault here is C819, a 1µF 50V electro which gives precisely the same symptom as this Teac displayed now. I examined this carefully (C819 equates with C714 in the Teac) but made no progress.

Next, I tried heating and freezing the components around IC701 and found R706, D736, C714 and C709 to be most affected by temperature. Then I began to notice more and more that there were differences between the parts shown on Teac circuit and those that were actually fitted to the set; eg, C712 is shown as 0.1µF on the circuit but a 330pF 1kV unit is fitted. Also, R714 is shown as 10kΩ but a 15kΩ resistor is fitted instead. I found more differences in other parts of the chassis but they weren't particularly relevant to this fault.

So, was the circuit correct or were the parts on the chassis correct? In the end, I decided to go with what was fitted – after all, the set had worked for six years without any trouble until now. I replaced R706, D736 and C709 and even C714 for the third time but it still made no difference.

By now, I had reached the stage where I was drawing out the component layout in an effort to get to grips with it. And it was while I was drawing this layout that I noticed that C714 was shown on the circuit with its positive lead to chassis whereas in the set, it had been installed the other way round. I fitted another 1µF capacitor with the polarity reversed and tried the set again. This time, the 122V rail remained stable and there was no rustling sound – the PC board had been incorrectly marked!

Black cat

Triumphantly, I shot back with the chassis and refitted it but there was still no picture. I couldn't believe this – what black cat had I seen recently? I didn't recall walking under any ladder or being involved in any other such jinx.

But it did occur to me that because the fault was producing a high and rising HT, there could be components that might have been destroyed by the high voltage. I momentarily, shorted the red gun of the tube to chassis while the set was on and a bright red horizontal line appeared – the vertical IC (IC507, TDA3654) had been destroyed!

Once again, I took it back to the workshop, installed a replacement IC, then returned and refitted the chassis. This time – at long last – success! The picture was now fine and a few minor adjustments completed the job.

I told my friend that I still wasn't sure this had fixed the original intermittent fault but to keep an eye on it and let me know. Three weeks have gone by since and all is well but my fingers are still tightly crossed. **SC**

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If you work in education, are new to electronics or would simply like to learn about digital instruments, then this project is for you.

A sound background

In basic terms, a PC sound card provides an interface between the analog world and the digital internals of a PC. Signals appearing on the sound card inputs are first coupled to an analog multiplexer/mixer and then piped to an A-D (analog-to-digital) converter. Depending on your appli-

cation software, the resultant "stream" of digitised data from the A-D converter may be further manipulated (filtered, enhanced, etc), transported elsewhere (eg, to the Internet) or just saved as a file to the hard disk.

During playback, the reverse process occurs. The digitally encoded audio data is converted back to analog format by the sound card's D-A converter, then filtered, amplified and fed to the loudspeaker and/or line output sockets.

For the technically curious, a simplified block diagram of a typical sound card is shown in Fig.1. As you can see, there's a little more to it than we've described. Analog and digital audio from a range of sources can be mixed and level-shifted along both the input and output signal paths.

Software-based instruments that provide stimuli, such as sound generators, utilise the sound card's D-A converter and analog output circuitry. Generally, sound card outputs can directly drive external circuitry, so no additional hardware is required.

By contrast, instruments that need to acquire data, such as oscilloscopes, do so via the sound card's analog input circuitry and its A-D converter. Software is then used to interpret the digital data stream and generate a graphical waveform display similar in appearance to conventional CRT-based (analog) oscilloscopes.

All that's left to do then, is to apply the signals to be examined to the sound card's inputs in suitable form. And that's where the hardware part of our project comes in.

Getting attached

This simple adapter circuit provides a simple oscilloscope-like interface between the signals we wish to meas-

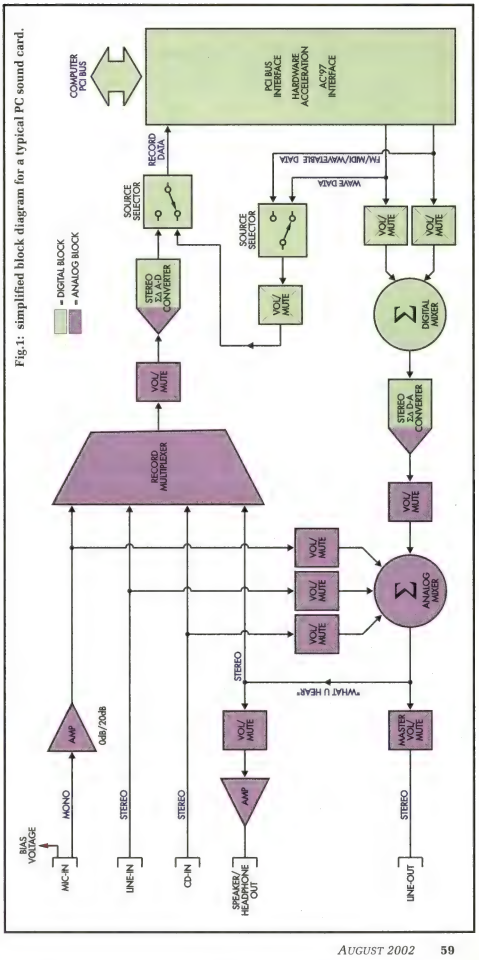


Fig.1: simplified block diagram for a typical PC sound card.

CHOOSING SOFTWARE

This adapter circuit is basically designed to allow you to connect test probes to your PC's sound card. Once the signals are in, software does the rest.

There are many digital instrument software packages available via the Internet, either as freeware or shareware. Our feature article on page 7 has a rundown on the some of the more popular packages that you can use.

Parts List

1 PC board, code 04108021, 125mm x 62mm
1 plastic instrument case, 129 x 67 x 42mm (L x W x H) (Altronics H-0203)
2 single-pole 12-position PC-mount rotary switches (S1, S2)
2 knobs to suit above
1 M205 500mA fast-blow fuse
1 M205 in-line fuseholder (DSE P-9962)
4 M3 x 10mm pan head screws (to attach shield)
8 M3 nuts
11 M3 flat washers
1 M3 star washer
1 M3 solder lug
1 2m length medium-duty figure-8 cable
1 80mm length light-duty hook-up wire
1 75mm length (approx.) tinned copper wire for links
1 PC board pin ("matrix" pin)

Semiconductors
2 TL071CP JFET-input op amp ICs (IC1, IC2)
1 TC7660HCPA (Microchip Technology) or ADM660N (Analog Devices) 120kHz voltage inverter IC (IC3) (Farnell 703-655)
2 1N751A 5.1V 0.5W zener diodes (ZD1, ZD2)
4 1N4148 small-signal diodes (D1 - D4)
1 3mm high-efficiency red LED (LED1)

Capacitors
1 220µF 16VW PC electrolytic
2 100µF 16VW PC electrolytic
2 10µF 16VW SMD tantalum (surface mount)
2 0.1µF 100V MKT polyester
4 0.1µF 50V monolithic
2 56pF 50V ceramic
2 18pF 100V ceramic (Farnell 236-950)

Resistors (0.25W, 1%)
2 1.5MΩ (Farnell 336-701)

2 1MΩ	2 3kΩ
2 200kΩ	2 1kΩ
2 150kΩ	2 470Ω
4 100kΩ	1 330Ω
2 27kΩ	2 100Ω
4 20kΩ	2 10Ω

Connectors
2 horizontal PC-mount BNC sockets (Altronics P-0529)
1 3.5mm sub-miniature PC-mount stereo socket (Altronics P-0096)
1 2.5mm PC-mount DC socket (Altronics P-0621A)
1 2.5mm cable-mount DC plug
1 15 pin male 'D' connector with backshell

Miscellaneous
Shielded stereo cable for connection to sound card (3.5mm plug to 3.5mm plug); 125 x 62mm sheet of stiff cardboard/elephantide or light-gauge aluminium for shield (see text); oscilloscope probes.

ure and the line input on the sound card. Although we could connect our test probes directly to the sound card's input, we'd be limited to measuring signals of just 0-2V peak. Not only that, but the card's input would "load down" high impedance circuits such as op amp inputs and the like.

To overcome these problems, the adapter provides a fixed high (1MΩ) input impedance, as well as a 6-stage attenuator to allow signals of up to 10V peak to be measured. And with a x10 oscilloscope probe, the range is extended to 100V peak.

In addition, an op amp stage amplifies the input by a factor of 10, thereby significantly improving the signal-to-noise ratio when measuring low-level signals.

How it works

Fig.2 shows the complete circuit diagram of the adapter. There are three main sections, labelled "Channel 1", "Channel 2" and "Power Supply". As the two channels are identical, we'll only describe channel 1.

Signals applied to the BNC connector (CON1) are AC-coupled to the input circuitry via an 0.1µF capacitor. A string of resistors to ground along with an 18pF capacitor provides the necessary high input impedance (1MΩ). In conjunction with rotary switch S1, these resistors also function as a voltage divider for input signal attenuation.

In all, six ranges are provided, with the topmost position passing the signal through to op amp IC1 without attenuation.

To protect the op amp (and therefore the sound card) input, signal levels are clamped by D1 and D2 to within 0.6V of the positive and negative supply rails. The 1kΩ resistor shown to the left of the diodes limits the current through D1 and D2, while the 470Ω resistor limits the current into the op amp's non-inverting input (pin 3).

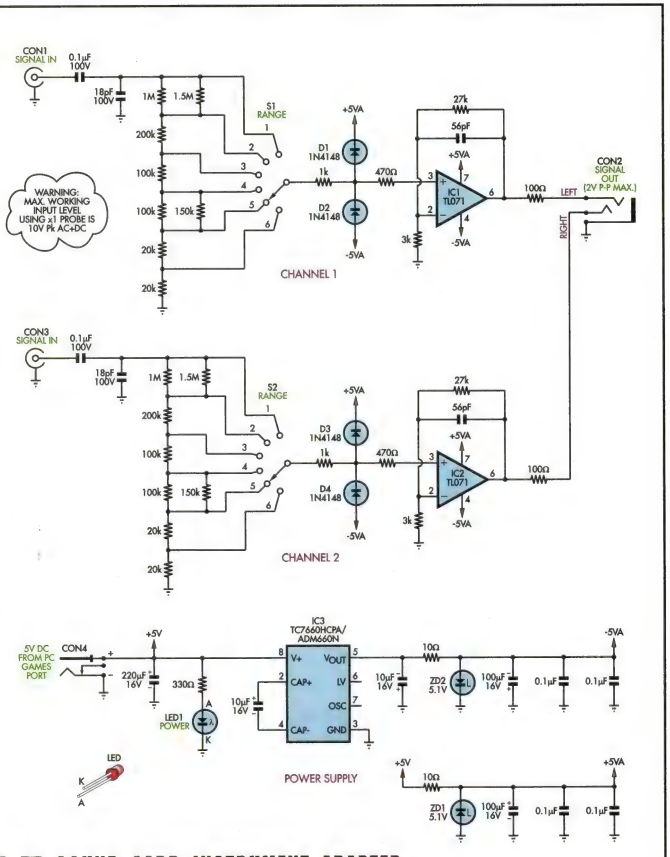
Zener diodes ZD1 and ZD2 also form part of this protection scheme. Because the impedance of the supply rails is quite high, they could easily be driven above their nominal values by a large input excursion. ZD1 and ZD2 prevent this from happening by breaking down above 5.1V. This scheme also protects the inputs when power is not applied to the adapter.

Input protection is limited to ± 100V maximum. This allows for times when you are measuring a level above 10V using the x10 attenuation of your probe but forget to slide the attenuation switch from x1 to x10. **Don't be tempted to poke around in high voltage equipment (live mains circuits, for example) – you will certainly "smoke" the adapter and perhaps your PC and yourself into the bargain!**

Op amp IC1 (TL071) is a high input-impedance, low-distortion amplifier designed for audio work. In this circuit, it is configured for a gain of 10, with a frequency response of about 100kHz. The 100Ω resistor in series with the output provides short circuit protection and isolates the op amp from the cable and sound card input capacitance.

To keep costs to a minimum and eliminate the need for yet another plugpack, we decided to power our project directly from the PC's +5V supply rail. As luck would have it, the +5V rail is accessible via the sound card's joystick port connector, usually situated right beside the audio input/output sockets.

Power enters the adapter via a standard 2.5mm DC socket. A little "brute-force" filtering is then applied using a 220µF capacitor followed by a low-pass RC filter formed by the combination of a 10Ω resistor and a 100µF capacitor.



SC PC SOUND CARD INSTRUMENT ADAPTER

Fig.2: this is the complete circuit diagram for the adapter. It consists of two switched attenuator channels which drive op amp output stages IC1 & IC2. Power (+5V) comes from the PC games port, with IC3 (a charge-pump voltage inverter) generating a -5V rail.

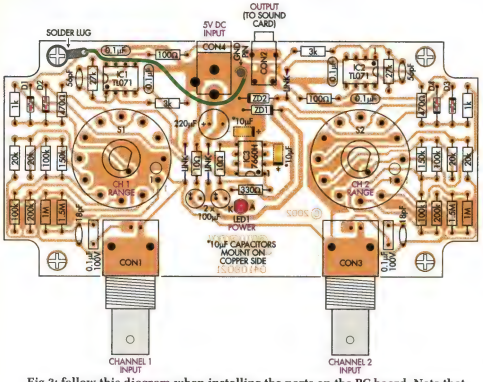


Fig.3: follow this diagram when installing the parts on the PC board. Note that the two 10µF SMD (surface mount) capacitors adjacent to IC3 are installed on the copper side of the board, as shown in one of the photos.

The TL071 op amps (IC1 & IC2) require both positive and negative supply rails. The negative rail is obtained by inverting the +5V rail using a charge pump voltage inverter (IC3). We chose a TC7660H device for this job because its 120kHz switching frequency is well above the audio spectrum. In addition, we've used surface-mount capacitors in the pump circuit to reduce radiated noise that could otherwise easily find its way into the high impedance attenuation networks.

The -5V (nominal) output on pin 5 of the inverter is cleaned up using a second low-pass filter, which removes most of the ripple and noise. Finally, high frequency decoupling of the 5V rails is provided using four 0.1µF ceramic capacitors.

Preparing the case

Before mounting any components on the PC board, you will need to perform some minor surgery on the case internals (assuming that you are using the recommended case).

Initially, the PC board should fit neatly inside the lip of the case but will rest on top of the integral guides. If it's a little oversized, then trim the board to fit using a fine file.

Next, cut away all of the guides with sidecutters or a sharp knife so that you're left with reasonably smooth internal surfaces. The PC board should now slide all the way into the case.

That done, you can complete the case preparation by drilling and filing the required holes in the lid and sides. The easiest way to get everything to line up properly is to photocopy the templates in Fig.6, cut them out and tape each one to the indicated faces of the case. You can then centre-punch directly through the templates to get accurate targets for drilling.

Always start with a small drill size and work up to the required size in several stages. The larger holes can be finished off using a tapered reamer.

Board assembly

Using the overlay diagram of Fig.3 as a guide, begin by installing the three wire links and all the resistors. Follow with the capacitors, noting that the electrolytic types are polarised and must be oriented as shown.

The two 10µF tantalum capacitors are miniature surface-mount devices that need to be mounted on the solder (copper) side of the board. The mounting area must be well tinned, clean and free of excess solder. Position the banded (positive) end as shown in Fig.3 and solder the device in place using a fine-tipped iron.

After soldering, use your meter to check for solder bridges between pads, as they can be difficult to spot with the naked eye.

Install the diodes (D1-D4, ZD1, ZD2) next, aligning the cathode ends (marked with a band) as shown.

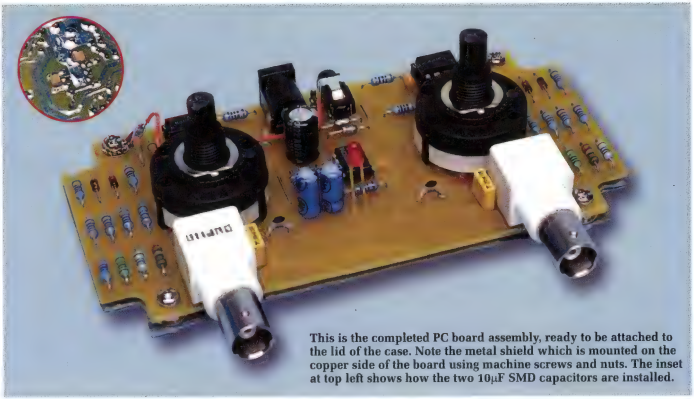
IC1, IC2 & IC3 can go in next and again, orientation is important. These are static-sensitive devices, so it's a good idea to wear an earthed anti-static wrist strap and to use a soldering iron with an earthed tip. Once they're in, install the four connectors (CON1-4) and the GND pin. Before soldering, ensure that they're seated squarely against the surface of the PC board.

The two rotary switches (S1 & S2) are next on the list. Before installation, they need to be reconfigured to limit their rotation from the default of 12 positions to just six positions. To do this, remove the nut, washer and locking ring. Notice how the tab on the locking ring can be inserted into one of 10 holes, numbered 2-11. Reinsert the tab in the number "6" hole and check that you have six possible shaft positions.

Repeat this procedure for the sec-

Table 1: Typical PC Sound Card Specifications

Frequency response	20Hz - 20kHz
Signal to noise ratio	>90dB
Total harmonic distortion	.01% @1VRMS into 10kΩ
Line-in impedance	47kΩ
Line-in sensitivity	2V P-P
CD audio-in impedance	50kΩ
CD audio-in sensitivity	2V P-P
Microphone-in impedance	600Ω
Microphone-in sensitivity	10-200mV P-P
A-D & D-A resolution	16 bits
Sample rate	4-48kHz
Output power (speaker-out)	3W into 32Ω (6W into 4Ω on some models)



This is the completed PC board assembly, ready to be attached to the lid of the case. Note the metal shield which is mounted on the copper side of the board using machine screws and nuts. The inset at top left shows how the two 10µF SMD capacitors are installed.

ond switch and then solder them into position. Once again, make sure that they are seated firmly against the PC board surface.

The last component to be mounted is LED1 (the power indicator). Slip the LED into place with the flat (cathode) side aligned as shown in Fig.3 but don't cut the leads short or solder it just yet.

Next, remove the nuts and washers from the rotary switches, leaving the locking rings in place, and fit the case lid. That done, turn the assembly upside-down and manoeuvre the LED into its hole in the lid. Ideally, the shoulder of the LED should be slightly proud of the inside surface of the lid. Now solder and trim the leads.

Making the power cable

Fig.4 shows the wiring for the power cable. You can see that we've opted to fuse the +5V rail right at the source, using an in-line fuse. This provides an extra measure of safety should the tip of the DC plug accidentally contact something that it shouldn't!

To protect the cable and provide effective strain relief, use a couple of layers of heatshrink tubing or insulation tape on the cable at the point where it passes through the backshell clamp. The clamp needs to have a firm hold on the cable to prevent stress on the solder joints.

Testing the power cable

Don't be tempted to skip this step! Before connecting the cable, use your multimeter to verify that the positive and negative wires are not shorted together. Next, plug the cable into the joystick port and with your multimeter set to "DC Volts", carefully measure the voltage at the DC plug. The tip (or "centre") of the plug should measure +5V (±0.25V) with respect to the outer shell.

If you measured +3.3V instead of +5V, then unfortunately you have one

Table 2: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
2	1.5MΩ	brown green green brown	brown green black yellow brown
2	1MΩ	brown black green brown	brown black black yellow brown
2	200kΩ	red black yellow brown	red black black orange brown
4	100kΩ	brown black yellow brown	brown black black orange brown
2	27kΩ	red violet orange brown	red violet black red brown
4	20kΩ	red black orange brown	red black black red brown
2	3kΩ	orange black red brown	orange black black brown brown
4	470Ω	yellow violet brown brown	yellow violet black black brown
1	330Ω	orange orange brown brown	orange orange black black brown
2	100Ω	brown black brown brown	brown black black black brown
2	10Ω	brown black black brown	brown black black gold brown

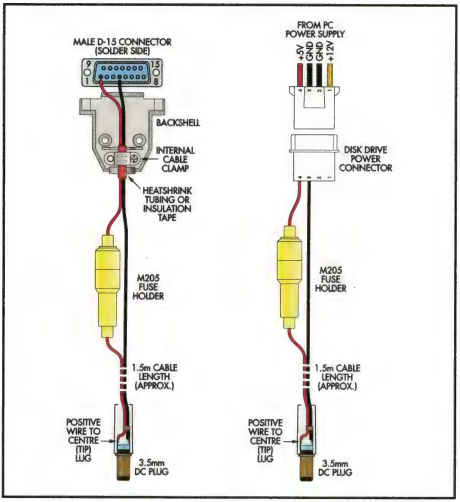


Fig.4: these diagrams show how to make the power supply cables. Note that the cable at right is only necessary if your games port supplies +3.3V instead of +5V.

of the few late-model cards that provide this lower, non-standard voltage on the game port connector (so much for backward compatibility!). In this case, you will need to delve into your PC's internals to get access to the +5V rail. A spare disk drive power connector is a convenient connection point.

Fig.4 also shows the wiring details for this alternate power supply connection scheme.

Basic checks

Before we're ready to connect the stereo cable and launch the software, we need to perform a few quick DC voltage checks on the completed board.

The following measurements are all with respect to ground. Simply connect the negative lead of your multimeter to the ground point provided by the PC board GND pin (between CON2 & CON4) and use the positive lead to make each measurement.

Apply power and check that you have +5V (±0.25V) at pin 8 of IC3, pin 7 of IC1 and pin 7 of IC2. Next, check for -5V at pin 5 of IC3, pin 4 of IC1 and pin 4 of IC2. Note that with the losses in the voltage inverter circuitry and the ±5% margin on the +5V rail, the negative rail should fall within approximately -5V to -4.55V.

Finally, rotate S1 and S2 to position "6" (fully clockwise) and measure both op amp outputs. They should be within a few millivolts of the ground rail.

The metal shield is exactly the same shape and size as the PC board. It can be made from a thin sheet of tinplate or by gluing aluminium foil to a piece of stiff cardboard or elephantide insulation material.

Shield's up

The adapter's high input impedance makes if susceptible to radiated noise in its immediate environment. Typically, the 240V AC mains and your PC's monitor are the worst noise generators. To minimise noise pick-up, the adapter could be installed in a metal case but to keep costs to a minimum, we've presented the finished project in a plastic instrument case instead. We achieved good results without a metal enclosure by fitting a shield (or "ground plane") to the underside of the PC board.

The shield is exactly the same dimensions as the PC board and can be fashioned from a variety of materials. We glued ordinary heavy-duty aluminium cooking foil to one side of a sheet of elephantide material and then cut out the required shape with kitchen scissors. Any thin conductive material should be suitable but ideally, it should be insulated on one side so as not to short protruding component leads to ground.

An old scrap of blank single-sided PC board material would also be a good choice.

To fix the shield to the underside of the board, first insert an M3 x 10mm screw in the corner hole closest to IC1. This screw will be used as the ground connection point, so place a star washer and solder lug under the head before winding up a nut from the copper side of the board. That done, fit screws and nuts to the remaining three corners, then invert the board and place flat washers on all four screws.

Next, with the conductive side facing away from the PC board, slide the shield over the screws (you remembered the holes, right?), install another four flat washers and wind on the remaining nuts.

Make sure that all component leads are well clear of the shield and use your meter to verify that the shield makes good electrical contact with the lug. To finish the job, connect the solder lug to the ground pin (between

The DC power socket and the output socket (for the sound card) are accessed through matching holes in the rear panel.

CON2 & CON4) using a short length of light-duty hook-up wire.

Signal generator cable

Well, that completes the hardware that you'll need to use with the oscilloscope and spectrum analyser software. If you'd also like to use the sound generator included with many software packages, then the only additional requirement is a simple cable – see Fig.5.

All analog signals from your sound card are AC-coupled to their output sockets, hence the need for the termination resistors. Be sure to insulate all connections and use insulated crocodile clips or probes.

Quantifying measurements

Most digital instruments provide some degree of input level (gain/attenuation) selection. Add to this the range switches on the adapter, and it can all seem a little confusing! Just how do you determine the magnitude of your measurements?

The 2V positions on the adapter's range switches pass the measured signal without any change in level. Ranges below this point provide amplification (gain) of the input signal, whereas ranges above provide attenuation. The table included on the front panel (see Fig.6) lists a multiplier, or scale factor, that can be used to calculate the actual signal level.

For example, with 8.5V input to the adapter and a switch position of 10V, the voltage applied to the sound card input will be 8.5 x 0.2 = 1.7V.

Let's try that in reverse. If your digital oscilloscope is set to 500mV/div and the waveform peak measures 1.5 divisions, then the voltage at the sound card's input must be 750mV. So, if the

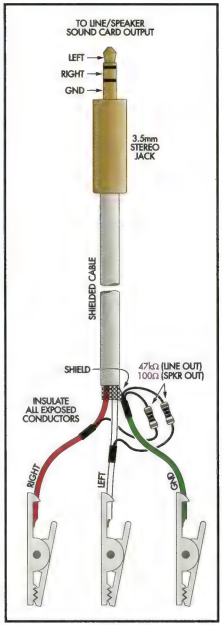
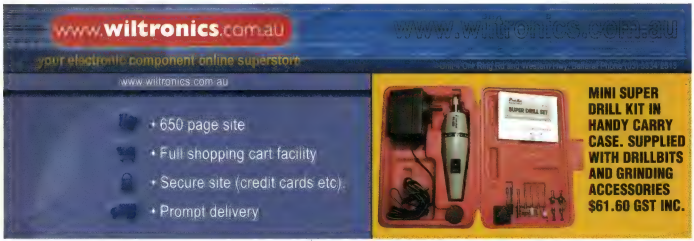
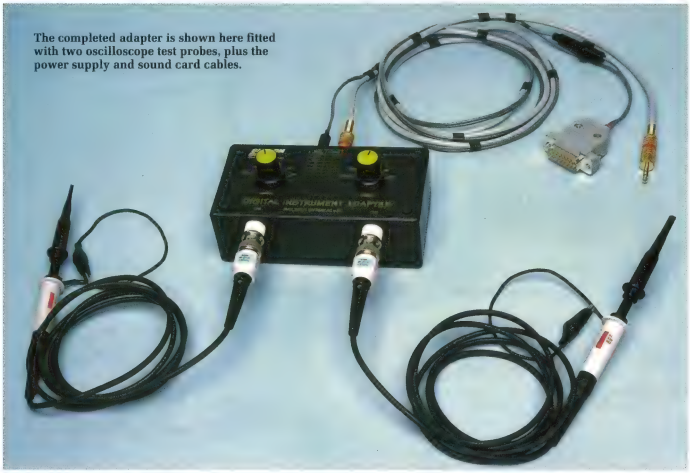


Fig.5: this cable can be used if you'd also like to use the signal generator instrument included with many software packages.





The completed adapter is shown here fitted with two oscilloscope test probes, plus the power supply and sound card cables.

adapter range switch is set to 500mV, then the actual applied voltage is 1/4 x 750mV = 187.5mV (or 132mV RMS).

Note that if you set your oscilloscope to read 2V/div, then the adapter switch positions now directly reflect what you see on the screen. With the adapter switched to 200mV, you're reading 200mV/div; and at the 500mV setting, you're reading 500mV/div, etc.

Digitally accurate?

It's important to be aware of the limitations of your new digital instruments before relying on them for serious work. In practice, the resolution and accuracy of any measurement system that relies on a sound card depends on the characteristics of the card itself. Table 1 lists the specifications of a typical sound card.

The frequency response of the card will also be the bandwidth of the digital instruments ('scope, multimeter, spectrum analyser, etc). This assumes that you've set the sampling rate to maximum (usually either 44kHz or 48kHz). This also means that it you measure signals above 22kHz, the results will be inaccurate. That's because the sampling rate must be at least double the signal frequency.

A sound card's 16-bit A-D converter can measure 65,535 discrete voltage levels, so with a 2V span it has low μV resolution. However, this doesn't mean that your digital instruments will be able to measure signals in the μV range! In practice, the PC power supply, sound card, cable and adapter all add a certain amount of low-level noise (called the noise "floor"), so that the smallest voltage you'll be able to measure accurately will be in the mV range.

Our prototype showed less than

The PC board is installed by first inserting the BNC connectors through their holes and then flexing back the rear of the case slightly as the back of the board is lowered into position.

1mV RMS noise but this will almost certainly be different on your system.

Most software includes at least rudimentary calibration for the line-in socket. You'll need a sinewave signal generator and multimeter for some, while others utilise their inbuilt digital signal generators and a line-out to line-in loop cable for the task. Be sure to check the documentation for details, as methods vary considerably.

If you wish, you can include the adapter in the signal loop during calibration to improve overall accuracy. Be sure to set the rotary switches to the 2V positions for 0dB gain.

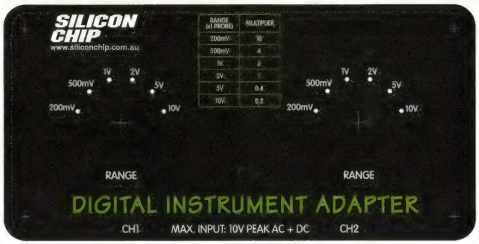
The maximum voltage that can be applied to the sound card's line-in socket is 2V P-P, or about 1.4V RMS. In practice, we found that our SoundBlaster Live card began clipping at just over 1V RMS. To ensure accurate measurements, it's a good idea to use the 'scope to check for clipping before switching to other instruments such as the spectrum analyser.

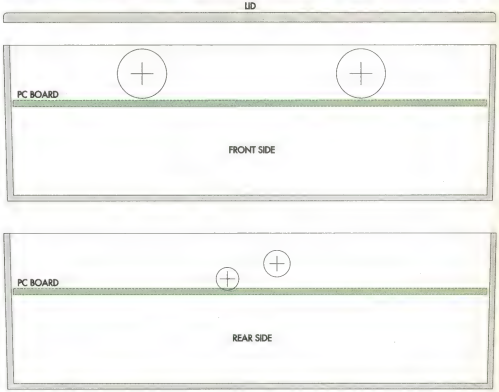
Staying alive

To wrap up, a word of warning about measurement techniques is in order. Be aware that the ground (0V) line of a PC's power supply is connected to mains earth. Because the adapter is effectively an extension of the PC circuitry, it's BNC connectors are also at mains earth potential. This doesn't cause a problem if the circuit you're probing is floating (ie, isolated from earth). If, however, the circuit has a return path to earth, then be sure to connect your probe's ground clip to a point that's also at earth potential.

If the chosen point is above earth potential, then current will flow around an earth "loop". If the potential difference is high, the results can be disastrous! A good example is the primary side of any off-line switchmode power supply. Connecting a probe ground clip to most points in one of these suckers will generate more fireworks than New Year's Eve on the Sydney Harbour Bridge!

Some readers would undoubtedly point out that this problem could be overcome by floating either the circuit under test or the test equipment itself (eg, by lifting the earth or by using an isolation transformer). Our advice is simple – don't do it! Seek advice from an experienced technician if you're not sure what you're doing! **SC**





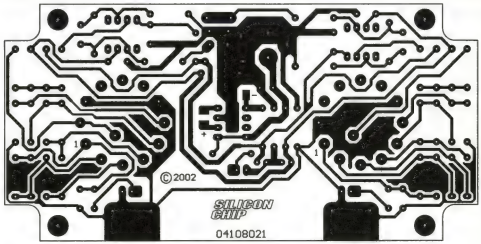


Fig.6: here are full-size artworks for the front panel (top), the front and rear panel drilling templates and the PC board pattern.

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Features: Soft ear pads • Gold plated 3.5mm stereo plug & 6.5mm adaptor • Samarium cobalt magnets

C 9004 Were $29.95 **NOW $25**

Speaker Stands!

Adjustable powdercoated speaker stands ideal for use in home theatre systems for satellite speakers. Adjustable from 600-1000mm. Top bracket suits speakers up to 190mm wide. **Sold in pairs.**

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BUY A ROLL AND SAVE A HEAP!

"Whopper" Wire

Flat style oxygen free cable for superior sound & low noise. Ideal for hooking up your hi-fi system.102/0.12 strand.

1/2 PRICE!

W 2140 RRP $2.00/m

NOW **$1/m** (50m Min)

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Heavy duty 24/0.20. Every workshop should have some! Dont be caught short on that vital project! Red/Black Only

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CLEAR THE COFFEE TABLE CLUTTER!

Styled along the lines of many major brand remote controls, this compact remote can be programmed to control up to 8 separate AV appliances. Features 32 storage keys for each device. Buy one today to control your TV, CD, DVD, Amplifier or VCR! Requires 2 AA batteries. **12 month warranty.**

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C 9024 RRP $29.95 NOW **$19.95**

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HIGH POWER HEAVY-DUTY VENTED DOUBLE MAGNETS!

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4Ω 10 Inch 500W Max.	4Ω 12 Inch 600W Max.
ONLY $159	ONLY $199
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This 150W sub-woofer amplifier will enhance your existing sound system and add a touch of realism to home theatre sound systems. HUGE BASS levels that will amaze your mates! Fully self contained the module is ideal for building into custom subwoofer cabinets. Fully featured, **JUST LIKE THE EXPENSIVE Hi-Fi STORE SUBWOOFERS,** with volume, crossover frequency control, phase switch, high and low level outputs.

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A 2450 Was $289 **NOW $189**

Features: • Auto Power On/Off with signal presence • Compact modular design • High and Low Level Inputs • High Level Outputs • Volume Control • Short Circuit Output Protection • Active Crossover variable from 50Hz ~ 150Hz • Phase Correction Switch • Power On Indicator • 240V Operation

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K 5600 $249

(SC 'Mar/April 2002)

Use one IR remote control to simultaneously adjust the volume of up to 6 channels. Perfect for Dolby 5.1 channel, active speaker & DIY surround sound systems.

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AMAZING PRICE!

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Q 0150 Was $799
Q 0174: Logic probes to suit **2 for $49, SAVE $34!** **NOW $599**

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BONUS OFFER! Purchase the Q 1080 & we will give you a Q 1082 datalogger RS232 interface valued at $26.25.

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Includes K-Type Temp Probe.

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A great tool for both home or workshop. Use it to glue together wood, plastics, paper, cardboard and ceramics. Very simple to operate, just turn it on, insert a glue stick, wait 5 minutes and your away! **Features:**
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ALL MODELS ARE B&W ONLY

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S 9095

S 9090 6" 2 channel Was $129.50, **NOW $115**
S 9093 10" 1 channel Was $199, **NOW $179**
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B& W CCD CAM MADNESS!

CCD Waterproof Bullet Camera IR illumination.
A fully sealed camera ideal for use in humid or water logged environments.

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CCD Waterproof Bullet Camera.
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B&W Dome Camera Features high quality SAMSUNG sensor with 380 lines of resolution. Compact design, easily adjustable.

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S 9110 RRP $109 **NOW $95**

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Can check all 8 conductors, as well as shielding integrity where shielded cable has been used. PLUS it can also check Coax wiring with the included adaptor!
Features: Auto/Manual mode • Will test 10Base-T, 10Base-2 RJ45, 258A, TIA 568A/568B and Token Ring • BNC to RJ45 Adaptor included **LIMITED STOCKS!**

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Get switched today with the amazing benefits switchmode supplies can provide. Greater efficiency, less weight, smaller size! Don't mess about with those old clunky linear transformers. All supplied in vented steel cabinets. 12V models only. **See catalogue page 199 for specs.**

- **M 8730** 25W 12VDC Was $79 **Now $70**
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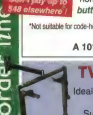
This **learning** remote can be used to combine several remotes or replace an old broken one. Suits things like garage doors, car or bike alarms, home alarm, etc. *• 4 easy program buttons • Wide operating frequency 260-500MHz*

Don't pay up to $40 elsewhere!

*Not suitable for code-hopping alarms

A 1015 RRP $41.95 NOW **$30**

TV WALL BRACKET



Ideal for mounting monitors or televisions for rumpus room or study. Suits TV's from 20-29" up to 75kg.

H 8114 WAS $179 NOW **$139**

240V mains power anywhere, anytime from your car battery!

2000W surge : 680W continuous power : 12V

This compact inverter is ideal for running power tools, small pumps, fluorescent lighting.

Features: • Reverse polarity protection • Output overload protection • Over temperature protection • Low battery voltage shutdown

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1200W surge : 380W continuous power : 12V

Ever been stuck out in the sticks without power for that crucial appliance? This inverter is perfect for powering small appliances

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M 8116 Was $219 **Now $169**

Multi Voltage Charger

A complete regulated power supply and battery charger in a compact PCB module. Can be configured to deliver 6,12 or 24V DC. Short circuit protection and intuitive mains failure detection.

Perfect for alarm panels!

M 8585 5 Amp RRP $115, NOW **$99**

CLEAN UP YOUR POWER!

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- **P 8131** 1Way+Phone Was $24.95 **Now $20**
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The perfect lab power supply!

Output voltage is adjustable from 3 to 15 volts, at up to 25A. Includes digital volt & amp meters for precise adjustment, overload & over temperature protection. Ideal for R & D, service benches etc.

3 to 15V @ MASSIVE 25A CAPACITY!

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FREE! Pick up a free Q 1121 Digital Multimeter with each M 8224 sold this month. It features 19 ranges with transistor and diode test functions. **Valued at $19.95!**

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"KNIGHT RIDER" LED CHASER KIT

(SC 'May 2002) Create a variety of visual effects with this 32 LED chaser project. Ideal for use in a visual display. ***Features:*** 12 switch selectable light patterns • Adjustable pattern speed • Adjustable LED brightness • 2 pattern medleys • 12VDC supply required

K 5815 $44.95

REMOTE TOUCH PLATE DIMMER

(SC 'Jan 2002) Replace that old fashioned light dimmer with a modern touch plate dimmer.

Features: Slimline appearance • Soft start for lamp • Last dimming setting restored when switched on • Remote control operation • RFI suppression

K 6030 $69.95
A1009 Remote to suit $39.90

Universal Fast Charger

(SC June/July '01)

A multipurpose fast charger to charge NiCAD , lithium ion, SLA and 6 & 12V batteries in a flash. ***Features:*** • 1.2, 2.4, 3.6 ,4.8 , 6, 7.2, 9.6, 12, 14.4V voltage steps • Time out & fuse protection • NiCad refresh • 240V operation

Keep those batteries in tip top condition!

K 1672 Was $229.95 **Now $199**

BATTERY GUARDIAN KIT

(SC 'May 2002) Stop your car fridge from running your battery flat. ***Features:*** 10A rating • Low power consumption • Cutout alarm • LED indication of cutout • Automatically re-connects battery power

K 4080 $47.95

MULTI-POWER BENCH TOP R & D MATE

(SC 'April 2002) An inexpensive, but very flexible bench top power supply. Ideal for R&D

Features: Six selectable steps- ±3.5 ,6 ,9, 12 & 15V DC • Use 9-15V range at the same time as 3-6V range • Independent load switching • Regulated rails

K 3200 $89.95

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(SC July, '2000)

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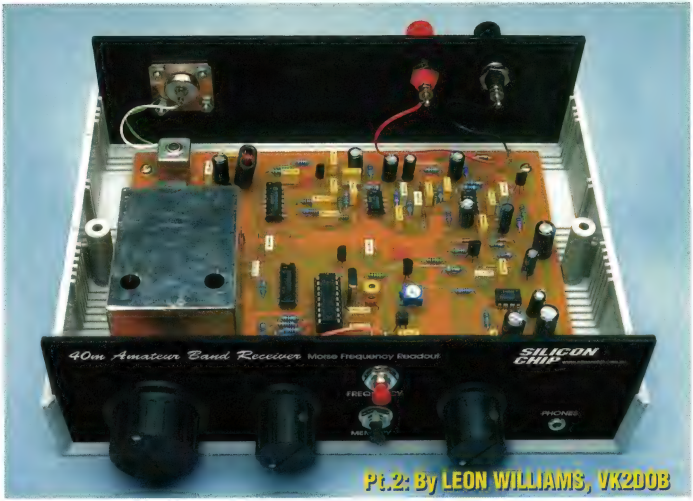


Pt.2: By LEON WILLIAMS, VK2DOB

Direct conversion receiver for the 7MHz amateur band

Last month, we gave the circuit details of this new Direct Conversion Receiver. This month, we conclude with the full construction and alignment details. There's also a few tips on using the completed unit.

A single PC board coded 06107021 (172 x 134mm) accommodates virtually all the parts, so building this receiver is really easy. Fig.5 shows the layout details.

Before installing any of the parts, check that the holes for the larger components such as the coil formers are the correct size. If not, enlarge them with a suitable drill bit.

The assembly can now be started by installing the seven wire links, making sure that they are straight and that they lay flat on the PC board. Follow these with the smaller components, such as the resistors, diodes, RF choke, trimpots and PC stakes. It's a good idea to check the resistor values with a digital multimeter before installing them on the board.

Because this is an RF project, it is important that you keep all component leads as short as possible to avoid any unwanted feedback and instability. In short, make sure that all components are mounted close to the PC board. This is also the reason why IC sockets are not used for the ICs, apart from the PIC chip.

Next install the headphone socket, IC socket and the capacitors. Start with the smaller capacitors and progress to the larger electrolytics, ensuring they

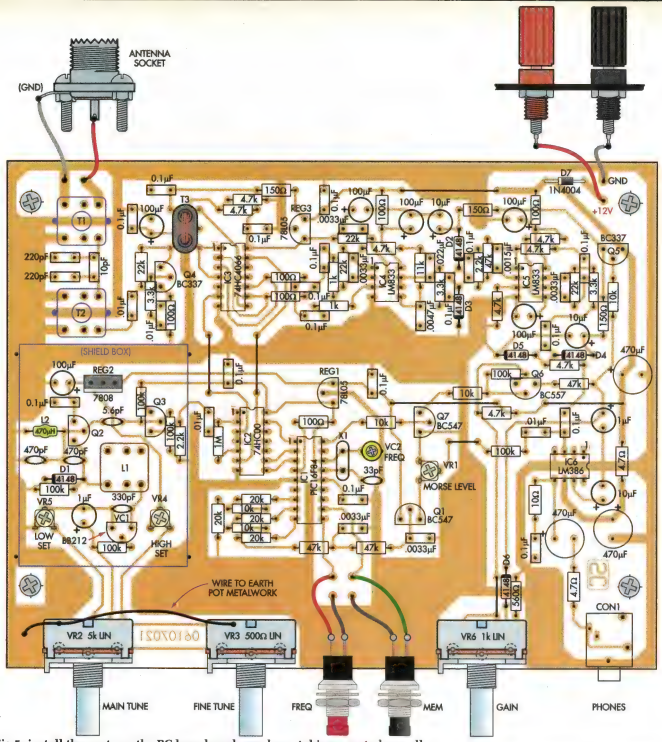


Fig.5: install the parts on the PC board as shown here, taking care to keep all leads as short as possible. The PIC microcontroller (IC1) is installed in a socket and should be left out of circuit until after the power supply checks have been completed.

are installed with correct polarity. Follow this with the transistors (Q1 & Q3-Q7), FET (Q2), voltage regulators (REG1-3), varicap diode package VC1, crystal (X1) and the ICs, leaving the PIC chip until later.

Note that the transistors, FET, BB212 (varicap diode package) and the small voltage regulators are all similar in appearance, so double check that you have installed them in the correct locations. The 8V regulator (REG2) runs cool and doesn't need a heatsink.

Winding the coils

Fig.6 shows the winding details for the coils, including the wire size, the start and finish pins and the number of turns required. If you are new to radio building and not familiar with coil winding, a few comments will probably be helpful.

All the coils need to be wound before they are installed on the PC board. Let's start with the BPF coils – T1 and T2. They comprise a 6-pin base, a metal can and a 5mm former into which a ferrite slug is screwed up and down to alter the inductance.

The first step is to place a drop of superglue on the bottom of a former (make sure that none gets into the threaded section) and then press it at right angles into the centre hole of a 6-pin base. Then, once the glue has set, you begin with the winding that has the larger number of turns.

COIL & TRANSFORMER WINDING DETAILS

WINDING	TURNS	START PIN	FINISH PIN
T1 PRIM	3	6	4
T1 SEC	20	1	3
T2 PRIM	20	6	4
T2 SEC	3	1	3
T3 PRIM	4	—	—
T3 SEC	8 + 8	—	—
L1	40	1	3

(ALL WINDINGS USE 0.25mm ENAMELLED COPPER WIRE)

Fig.6: the above table shows the winding details for the various coils. T1, T2 & L1 are wound on 5mm formers fitted with a 6-pin base, while T3 is wound on a ferrite 2-hole balun transformer. Note that T1 & T2 (but not L1) are fitted with ferrite slugs.

To do this, first run the wire down the inside of the start pin and solder it to the end of the pin. That done, start at the bottom of the former and wind on the required number of turns, keeping them next to each other in a single tight layer.

The trick now is to hold the turns tight while you run the free wire down the outside of the winding and inside the finish pin. Finally, solder to the end of that pin. Although the heat from the soldering iron should melt the wire enamel to allow soldering, you will probably find it easier if you scrape some of the enamel off the ends of the wires first. Cut off the excess wire from both pins when you have finished the winding.

It may sound difficult at first but it will become easier with practice. And here's a tip – wrapping a piece of adhesive tape around the winding makes it easy to keep it in place while soldering the wire to the finish pin.

You can now complete the coil by installing the winding with the least number of turns over the top of the first winding, starting from the bottom. Solder this winding to its respective start and finish pins as before, then screw in a ferrite slug.

The second BPF coil (T2) is wound the same way, noting the different pins for the start and finish of the windings. This coil is also fitted with a ferrite slug.

The mixer transformer (T3) is a bit different in that it is wound on a 2-hole balun former – see Fig.6. A turn here involves passing the wire up through one hole and then back down through the second hole.

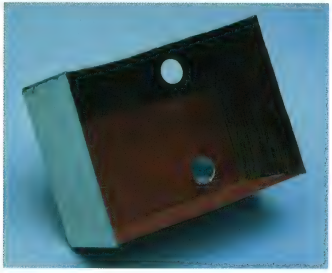
The secondary is wound first and consists of eight turns either side of a centre tap. To wind it, first take a

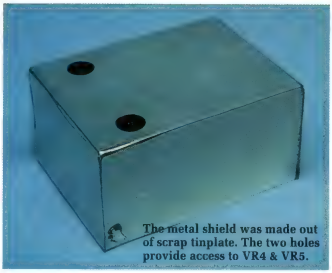
Table 2: Capacitor Codes

Value	IEC Code	EIA Code
0.1μF	100n	104
.022μF	22n	223
.01μF	10n	103
.0047μF	4n7	472
.0033μF	3n3	332
.0015μF	1n5	152
470pF	470p	471
330pF	330p	331
220pF	220p	221
33pF	33p	33
10pF	10p	10
5.6pF	5p6	5.6

Table 1: Resistor Colour Codes

No.	Value	4-Band Code (1%)	5-Band Code (1%)
1	1MΩ	brown black green brown	brown black black yellow brown
6	100kΩ	brown black yellow brown	brown black black orange brown
4	47kΩ	yellow violet orange brown	yellow violet black red brown
4	22kΩ	red red orange brown	red red black red brown
4	20kΩ	red black orange brown	red black black red brown
1	11kΩ	brown brown orange brown	brown brown black red brown
5	10kΩ	brown black orange brown	brown black black red brown
8	4.7kΩ	yellow violet red brown	yellow violet black brown brown
3	3.3kΩ	orange orange red brown	orange orange black brown brown
2	2.2kΩ	red red red brown	red red black brown brown
2	1kΩ	brown black red brown	brown black black brown brown
1	560Ω	green blue brown brown	green blue black black brown
3	150Ω	brown green brown brown	brown green black black brown
6	100Ω	brown black brown brown	brown black black black brown
1	10Ω	brown black black brown	brown black black gold brown
2	4.7Ω	yellow violet gold brown	yellow violet black silver brown





The metal shield was made out of scrap tinplate. The two holes provide access to VR4 & VR5.

length of wire about 600mm long and pass one end through one of the former holes, leaving about 50mm at the other side. While holding this short end in place, wind on eight turns around the centre of the former.

Now bend the remaining wire into a sharp 'U' shape about 20mm from the former and twist the wires together to form the centre tap. That done, continue winding another eight turns in the same direction as before. When completed, the ends of both wires and the centre tap should be at the same end of the former.

Next, move the secondary wires aside to avoid getting them mixed up. You can then complete the coil by taking another length of wire and winding on four turns over the top of the secondary to form the primary.

The local oscillator coil (L1) is wound in a similar fashion to the BPF coils, except that it only has one winding. You will need to make sure this coil is wound tight and the wire can't move. Any movement will alter the local oscillator frequency and move the station off tune. The easiest way to do this is to coat it with glue or silicone adhesive after it's wound.

Before soldering the coils into place, check that they sit neatly and that the formers are perpendicular to the PC board. Also, when installing the cans for T1 and T2, make sure that they are positioned centrally about the former so that the slugs can be screwed up and down through the hole in the top of the can.

The slugs used for T1 and T2 have a strip of rubbery material glued to one side. This is included to stop the slugs from moving during normal use and altering the tuning of the coils. You will probably find that this makes them quite difficult to move and excessive force on the brittle core can cause them to break.

If you find that this is the case, scrape away some of the rubbery material with a sharp knife so that they are still firm in the former but can be moved freely with an alignment tool.

Final assembly

Now for the final assembly. First, cut the pot shafts to the required length using a small hacksaw and break away the anti-rotation spigot. That done, install the three pots on the PC board, making sure that the correct pot goes in each location.

Next, scrape away some of the passivated coating on the top of the Main and Fine tune pots (VR2 & VR3) and connect a length of tinned copper wire between their bodies and also to ground on the PC board (see Fig.5). This stops 50Hz hum from being picked up by the pots and modulating the local oscillator.

A metallic shield must be placed over the local oscillator components so that it is not affected by quick changes in temperature or by external magnetic fields. This shield can be made from scrap PC board or, as in the prototype, constructed from tinplate (eg, from a food can).

Fig.7 shows how the metal shield is made. Begin by cutting out the cross shape, then drill the two holes and remove all burrs along the edges with a file. That done, bend the tinplate along the dotted lines and run a bead of solder on the inside of each corner where the sides meet. Finally, place the upturned metal box over the local oscillator components – the holes line up with trimpots VR4 & VR5 – and solder it to the four PC stakes.

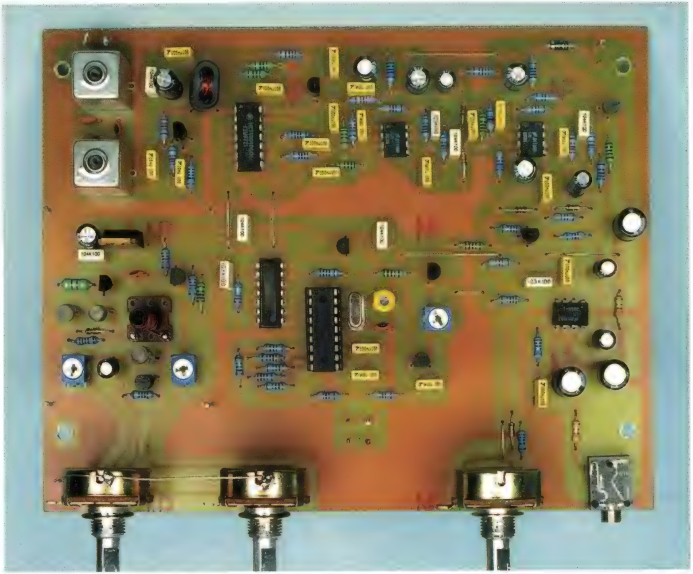
The PC board is now finished and you can start work on the case. Using the photographs as a guide, start by drilling the holes for the power supply binding posts and for the antenna socket on the back panel. The front-panel holes can then be drilled using the accompanying artwork as a template. You will need to drill three holes for the pots, two for the pushbutton switches and one for the headphone socket.

Alternatively, you can drill the holes in the front panel after first affixing the adhesive label. In each case, it's best to drill a small pilot hole first and then carefully enlarge the hole to the correct size using a tapered reamer.

Now, with the front and rear panels removed, place the PC board on the bottom of the case so that its front edge will butt up against the front

SOFTWARE

The PIC software files can be downloaded from the SILICON CHIP Web site. The files DCRX.ASM and DCRX.HEX are combined in a single zip file called DCRX-ASM-HEX.ZIP. To program your own PIC chip you will need the file DCRX.HEX, while studying the DCRX.ASM source code will reveal the secrets of how a humble PIC can measure high frequencies and sound Morse code!



This view shows the completed PC board assembly, prior to fitting the metal shield over the local oscillator section at lower left. The metal shield is secured by soldering it to four PC stakes.

panel. Note that the PC board will not sit flat at this stage, because some of the mounting pillars on the base interfere with the soldered connections. You can fix that by removing the offending pillars, either by drilling them out with a large drill or by cutting them off with a large pair of side-cutters.

Once the case is ready, install the antenna socket and the binding posts on the rear panel. Note that an earth lug must be attached to the antenna socket (it's secured by one of the mounting screws), to provide an earth connection point. The two pushbutton switches can also be installed on the front panel at this stage, with the red FREQ switch at the top.

Once that's done, attach the front panel to the PC board and secure it by installing the pot nuts and washers (the washers go behind the nuts). You can then slide the assembly into the slot at the front of the case and fasten the PC board in place using four small self-tapping screws.

Finally, fit the rear panel in place and wire the antenna socket, the power supply binding posts and the push-button switches to the PC board stakes using light-duty hookup wire.

Test & alignment

Before applying power, have a good look over the PC board one last time. A few moments spent here looking for components with the wrong value or in the wrong position could save you hours of frustration later on.

Once you are satisfied that everything is correct, follow this test procedure to check out the receiver:

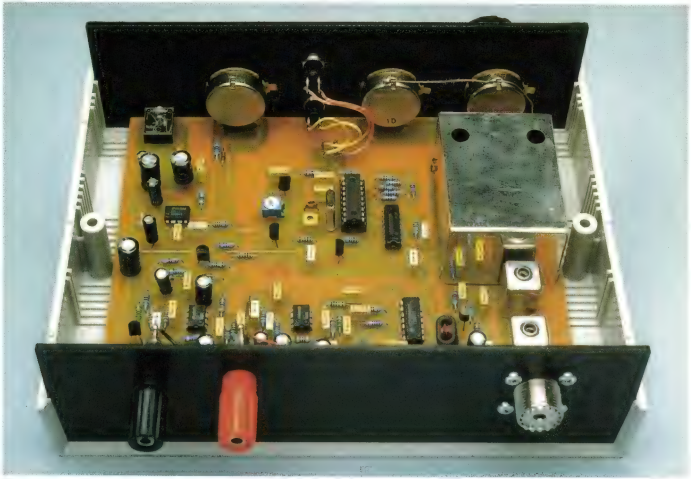
(1). Set all the trimpots and the front-panel controls to mid-position and plug a pair of headphones (or a loudspeaker) into the headphone socket.

(2). Connect the receiver to a regulated DC power supply of around 12V and connect a multimeter – set to read DC current – in series with the positive lead.

(3). Apply power and check that the current drawn is about 50mA. If you don't get this, switch off quickly and check for errors.

(4). Assuming all is OK, turn the Gain control (VR6) clockwise and check that you can hear some hiss in the headphones. This indicates that at least the audio stages are working.

(5). Disconnect the multimeter from the supply lead, reapply power and check the voltages at the outputs of



The rear panel carries the two binding post terminals for the power supply plus the SO239 antenna socket. You can replace the binding post terminals with a 2.5mm DC power socket if you wish but make sure you get the polarity right.

regulators REG1 and REG3. In each case, you should get a reading of +5V.

You can also check for +8V at the output of REG2. Note: you will either have to temporarily remove the metal shield or remove the entire assembly from the case (so that you have access to the underside of the PC board) in order to do this. All regulator outputs should be accurate to within 250mV. Once again, if any measurements are incorrect, switch off immediately and check for errors.

(6). If all voltage checks are OK, turn off the power and install the PIC chip. That done, reapply power and check that you hear three beeps in the headphones (each time power is applied, the PIC chip does a reset and generates three beeps to indicate that it is operating correctly).

(7). Press the FREQ switch and the frequency of the local oscillator should be heard. Don't worry about what it is at this stage – just use it to adjust the level trimpot (VR1) for an acceptable level in the headphones.

(8). If you have a signal generator, inject a low-level signal at about 7.1MHz into the antenna socket. Set the Gain control (VR6) for a relaxed volume and adjust the cores in T1 and T2 with a suitable alignment tool for maximum volume. The BPF is fairly broadband, so there is no need to stagger tune the two coils to obtain a flat pass band.

If you don't have a signal generator simply connect an antenna, tune to a station around the middle of the band and adjust the cores in T1 and T2 for maximum volume.

Freq. counter programming

Now that the receiver is operating, let's check the frequency counter operation and programming options. As previously stated, when you press the FREQ switch, the current frequency of the local oscillator is announced in Morse code.

In addition, each time either switch is pressed and acknowledged by the PIC software, a short burst of tone is heard in the headphones.

Pressing the MEM switch, however, gives one of two possible outcomes. If the next switch pressed is MEM again, the current frequency of the local oscillator is stored in the PIC's EEPROM memory and two beeps will be heard (the EEPROM retains its contents even if the power is removed). Alternatively, if the next switch pressed is the FREQ switch, the frequency stored in the EEPROM (not the current frequency) will be sounded in Morse code.

This is a simple single-memory store and allows you to store a particular frequency and then retrieve it at a later stage – unless you overwrite it of course!

Pressing the FREQ and MEM switches at the same time places the frequency counter in program mode and a long beep will be heard. At this point, pressing the FREQ switch toggles between long and short Morse modes. Long mode is where all the frequency digits are sounded; eg, 7123450. Short mode only sounds the kHz digits – in this example, the digits 123.

This option will be the normal set-

ting and is used to speed up the Morse sounding. In any case, you will normally know what the MHz digit is and we are not usually interested in the frequency digits below 1kHz unless we are doing some testing or alignment.

Pressing the MEM switch moves you onto the Morse speed setting, where two long beeps will be heard. Pressing the FREQ switch toggles between the three Morse speed settings. Pressing the MEM switch will return you back to the start of the programming mode.

Each time a length or speed option is selected with the FREQ switch during programming, the current frequency is sounded using the selected options.

Pressing both switches at any time exits programming mode and returns the frequency counter to normal operation. The program settings are stored in EEPROM and so do not get erased when power is turned off.

The very first time you power on the receiver, the values in the stored frequency area of the PIC's EEPROM will be unknown. As a result, strange readings may occur when the MEM and then the FREQ switches are pressed to read the stored frequency if one has not been stored previously. To avoid this situation, press the MEM button twice to store a valid frequency after the first power on. Once an initial frequency is stored in EEPROM, the MEM switch can then be used normally.

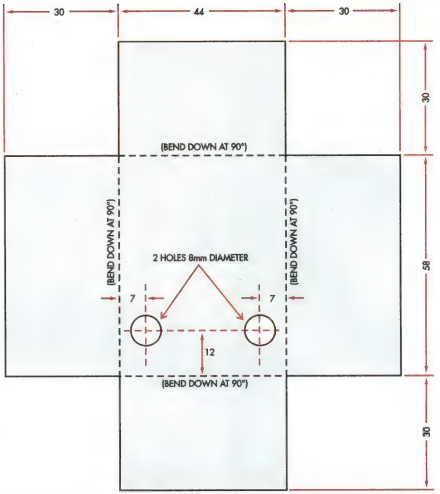


Fig.7: here's how to make the metal shield that goes over the local oscillator circuitry. Cut out the cross shape and drill the two holes before bending the tinplate down along the dotted lines.

Calibrating the counter

To check and adjust the accuracy of the frequency counter, you will need to connect an external frequency meter to pin 6 of IC2b. That done, press the FREQ switch and compare the frequency heard in Morse code with that displayed on the frequency meter. If they are the same or within a few tens of hertz, then no adjustment is really necessary.

If you do want to improve the accuracy, this can be done by adjusting VC1 with a small screwdriver and then pressing the FREQ switch to check the change. Continue until the frequency heard in Morse code is the same as that displayed on the frequency meter. If you can't get the frequency correct, you may have a crystal that's too far off frequency, so try another. You may also need to alter the 33pF capacitor if you have changed the crystal and are still having no luck.

Don't be too concerned about obtaining absolute accuracy, as the base

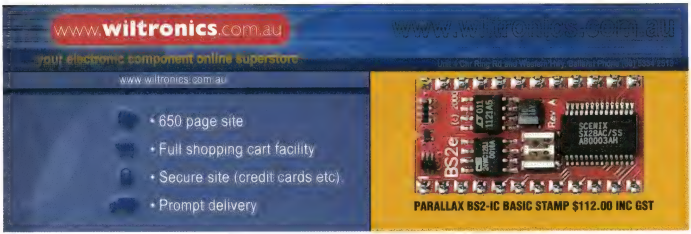


Fig.9: this front-panel artwork can be cut out and used direct if required. It can be protected behind a thin sheet of clear Perspex.

resolution of the PIC software counter is only ±10Hz. Also, in normal use, you don't need to know the tuned frequency to better than 1kHz accuracy. What's more, the PIC oscillator will probably drift to a small degree over time and with changes in temperature.

If you don't have access to a frequency meter, a reasonably accurate way of adjusting the crystal oscillator is to zero-beat to a known frequency carrier. At this point, the local oscillator and the carrier frequency will be the same. Press the FREQ switch and adjust VC1 as before.

Setting the LO

The local oscillator (LO) is a free-running HF oscillator and as a result it is quite normal for some frequency drift to occur immediately after power is applied. It stabilises within five minutes or so and drift after this warm-up period is quite small. For this reason, make sure the receiver is powered on for at least five minutes before adjusting the oscillator range.

At this point, you need to decide what the range of the local oscillator – and hence the tuning range of the receiver – is going to be. In the prototype, the lower frequency was set to 7.000MHz and the upper frequency set to 7.200MHz. The LO adjustment procedure is as follows:

(1). Set the Fine tune control (VR3) to mid-position and rotate the Main tuning control (VR2) fully anticlockwise, then move it a few degrees clockwise from the stop.

(2). Press the FREQ switch to check the frequency. Adjust the "Low Set" trimpot (VR5) with a small screwdriver and check the frequency again. Repeat this procedure until the frequency is at the desired lower limit.

(3). Rotate the Main tuning control (VR2) fully clockwise and then move it a few degrees anticlockwise from the stop. Now set the upper frequency limit in the same fashion as before, this time by adjusting the High Set trimpot (VR4).

Note that there is some interaction between the High and Low trimpot settings, so you may need to repeat the last two steps a couple of times to obtain the desired range.

It's also possible that you may not be able to set the range correctly, because of component tolerances or because the coil (L1) is way off its intended inductance. If you can't get the range low enough, try adding a turn or two to L1. Conversely, if the range is too low, take a turn or two off.

(4). Check the frequency range of the Fine tuning control by rotating it to one stop, pressing the FREQ switch and then rotating to the other stop and again pressing the FREQ switch. You should achieve a range of around 1-2kHz either way. Note: this simple fine tuning system results in more range at the high frequency end than at the low frequency end.

Once setup has been completed, attach the top case half with the two screws supplied and the receiver is ready for use.

Operation

Finally, here are a few tips to help you get the best from your receiver. First, when selecting a power supply, don't be tempted to use a standard 12V plugpack. These are generally unregulated, producing up to 17V or so with no load. More importantly, they produce large levels of hum and this will be injected into the sensitive audio stages of the receiver.

For this reason, it's best to use a small 12V regulated supply or a battery that's capable of supplying a few hundred milliamps. A regulated 12V or 13.8V DC plugpack or "power pack" is ideal. Don't use a switchmode supply though as this will almost certainly create noise problems.

Tuning SSB and CW stations is often difficult for the uninitiated. That's because the tuning is fairly critical and also because the tone of the audio changes as you tune across the signal.

The trick is to first set the Fine tune control to midway and tune in the signal as best you can using the Main tuning control. After that, it's simply a matter of slowly rotating the Fine tune control until the voice sounds natural. For Morse code signals, just adjust the Fine tune control until the audio tone is easy to listen to.

Because this receiver does not have an automatic gain control (AGC), you will need to adjust the Gain control to suit the level from different stations. Always start out with the Gain control set around three quarters and then advance it if the level of the signal is too low. If the gain is set too high and you are wearing headphones, a sudden burst from a strong signal will be most unpleasant.

The receiver was designed for headphone use and so the output power is not particularly high. However, an efficient loudspeaker mounted in a suitable enclosure can be used if preferred.

Finally, to get the best from the receiver, it should be connected to an antenna resonant on the 40m band

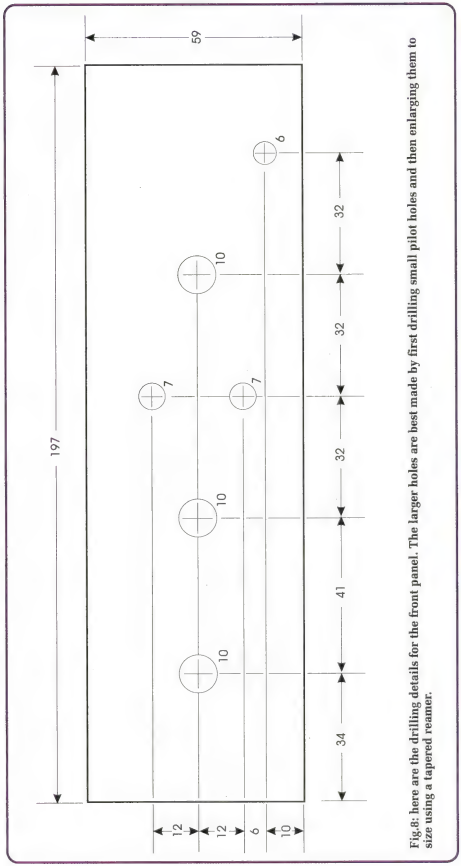


Fig.8: here are the drilling details for the front panel. The larger holes are best made by first drilling small pilot holes and then enlarging them to size using a tapered reamer.

and with an impedance of 50Ω. A good performing and easy-to-build type is a wire dipole fed with coaxial cable. If you don't have one already, consult an antenna book for guidance or search the Internet for designs. SC

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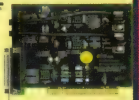

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PRODUCT SHOWCASE

OK, so what do you do with 'em?

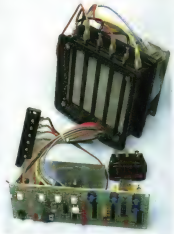
Branco Justic, head honcho at Oatley Electronics, has a well-earned reputation for sniffing out some intriguing products and then selling them at bargain prices.

One we spotted in last month's Oatley advert in SILICON CHIP is no exception. It's the innards of a 240V ceramic fan heater.

Apparently these failed QC so they weren't suitable for use as a heater but Branco couldn't resist them – or their controller PC boards (a couple of pallets of them!).

There are three separate ~800W ceramic heaters built into one unit, each individually connectable. Each is about 500Ω cold but around 65Ω hot (not linear). A 240V 80mm diecast fan blows air through the elements. At $15 each you're getting a very cheap fan (priced diecast fans lately?) and the heater elements effectively for nothing.

The question is, what can you use the ceramic heater for? Branco suggests they could be good for a variety of heating purposes (incubators, photo chemicals, etc), especially as they still produce good heat down to about 50V or so. Or perhaps they could form a high power dummy load. Or an interesting desk ornament/paper weight. Put on your thinking caps and see what you come up with!



The heaters are also supplied with a heavy duty 3-pole rocker switch. The controller boards are sold separately (with connection diagram but no circuits available). They have some triacs, opto couplers, a transformer and even a couple of mercury ("tilt") switches on them, all for just $12.00.

Contact:
Oatley Electronics
Ph: (02) 9584 3563 Fax: (02) 9584 3561
website: www.oatleyelectronics.com

Source for FETs with pilot lights . . .

AC Electronics have been appointed Australasian distributors of the Svetlana range of high quality audio vacuum tubes.

This includes the popular EL34 and 6L6GC tubes as well as the 300B, 6550C, KT88 and EL509. The long awaited Svetlana 12AX7 has just been released.

In addition they are stocking the large range of Golden Dragon tubes including the KT66 and KT88 GEC look-alikes and the super 300BM, plus the EI Yugoslavian Elite Gold series covering 12AT7, 12AU7, 12AX7 together with 6CG7, 6DJ8, 12BH7A and EL84 – all with gold plated pins.

For industrial and high-power transmitting requirements they distribute Global Tubes of the USA.

To complement their vacuum tubes, AC Electronics have also been appointed distributors of the Hammond range of "Classic" audio transformers for single-ended and push-pull/ultra-linear use.

They will also supply Hammond universal power transformers and chokes.

Contact:
AC Electronics
PO Box 487, Drysdale Vic 3222
Ph: (03) 5257 2297 Fax: (03) 5257 1773
email: acourtney@pacific.net.au

Weather forecast station has wireless (LIPD band) outside sensors

Everyone is interested in the weather – and what it will do next! Jaycar Electronics have a rather neat weather station which gives you the current temperature both inside and out (outside via a 433MHz wireless sensor) along with relative humidity and temperature trends. It also has an alarm clock and calendar inbuilt and it even has a storm warning alert and over/under temperature alerts.

The main display unit is 117 x 127 x 27mm so is large enough to be seen from quite a distance.

Extra sensors are available (approx. 30m range). With 1 sensor the unit (XC0295) is priced at $99.00

Contact:
Jaycar Electronics
PO Box 6424, Silverwater NSW 1811
Ph: (02) 9741 8555 Fax: (02) 9741 8500
website: www.jaycar.com.au

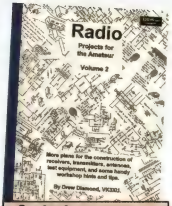
Radio Projects for the Amateur

Volume 2, the sequel to the now-out-of-print Volume 1, presents about 50 projects of interest to amateur radio operators, covering everything from receivers and transmitters through to test equipment and even antennas and masts.

The projects are presented very much in "amateur" style with hand-drawn circuit diagrams and component layouts. That's not a criticism, it's a style which many "home brewers" have become accustomed to because that's how they keep their own circuits etc filed away!

It's available direct from the author/publisher (see below) or through the WIA VK2 Division bookshop (http://members.ozemail.com.au/~vk2wi/bookshop/index.html).

Price including GST is $24.95.



Contact:
Drew Diamond
45 Gatters Rd, Wonga Park
Vic 3115

New clamp meters, tough leather cases from Fluke

Fluke has introduced a new, smaller-size range of clamp meters that fit more easily into tight places. The 321 and 322 meters measure to 400A AC and 600V AC, up to 400W. The 3322 will measure to 600V DC and has a 40A range for accurate low-current measurement. Both feature auto shut-off, soft-sided carry case, test leads, batteries and two year warranty.

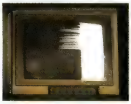
Also new to the Fluke range are three sizes of tough, premium cases, made from top grain leather with rugged snaps, reinforced rivets and heavy duty stitching.

There is one case for meters/test leads, one for electrical testers and another for all other accessories. All can be worn on a belt.

Contact:
Fluke Australia
Ph: (02) 8850 3333 Fax (02) 8850 3300
Website: www.fluke.com

How do you easily find a satellite signal?

With less and less analog transmission, finding a satellite TV signal these days by manual searching is becoming quite difficult. (For example, PAS-2 now has only digital signals). Sure, if you're a professional installer you can buy an $X000 Spectrum Analyser – but for most mere mortals they're a tad out of reach!



Satellite TV specialists Av-comm have come up with a much cheaper alternative – a Spectrum Monitor. This device connects to the satellite receiver and tells it to sweep over the band, without processing the received signals on the way. It then outputs any received signals as a video graphic which can be displayed on most video monitors via the video input.

Each satellite signal found (or more correctly each transponder) is shown as a new peak on the screen.

It's a quick-n-easy way to graphically display received signals – say, as your dish is swept across the sky. The larger the peak in the display, the stronger the received signal. And while it is not calibrated, the peaks have some relativity to each other as far as frequency is concerned (we've seen this device used with frequencies written all over the glass monitor screen in marker pen!).

It can also be used to set polarisation (simply by turning the LNB on the dish through 90° and checking for a peak).

If you're into satellite TV reception, always searching for new signals, the Spectralook from Av-comm could be a godsend. It is priced at $329 – dearer than a satellite signal meter but much, much more useful.

Contact:
Av-Comm Pty Ltd
Ph: (02) 9939 4377 Fax: (02) 9939 4376
website: www.avcomm.com.au

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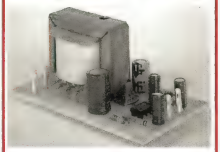


Manufactured in Australia
Harbuch Electronics Pty Ltd
9/40 Leighton Pl. HORNSBY 2077
Ph (02) 9476-5854 Fx (02) 9476-3231

Ultra-mini four-port USB hub

The Ultra-Mini 4 Port bus-powered USB Hub from Targus allows any notebook or desktop computer to enjoy plug and play connection with multiple input/output USB devices.

The hub is ultra lightweight and compact (95 x 42 x 20 mm) and has full overload protection on each port to prevent any danger of power shutdown, Each port glows blue when powered up. It comes with a 1m cable.

The hub is suitable for both PC and Apple notebooks or USB-enabled desktops with Windows 98, 2000, Me, XP or Mac operating systems.

The Ultra-Mini 4 Port USB Hub has a recommended retail price of $49.95 and is available throughout Australia wherever quality computer accessories are sold.

Contact:
Targus Australia
Ph: (02) 9807 1222
website: www.targus.com.au

VINTAGE RADIO

By RODNEY CHAMPNESS, VK3UG

The Ferris 214 Portable Car Radio

Ferris Radio concentrated predominantly on producing car radios, some of which were "portable" (and heavy) and could be used in a car on 6V or 12V or in the home on 240V AC. Here we look at their model 214 portable car radio which used germanium transistors.

As well as portables, Ferris produced some DC-to-AC converters and multiband car radios (BC band and a couple of shortwave bands). In addition, during the first few years of black and white TV, they produced a 32V vibrator-powered TV receiver; quite a boon in country areas.

During the era in which Australian manufacturers made transistor radios, Ferris produced some quite high-performance portable sets which could be used as car radios. AWA and Astor made similar units. They could be changed from car to portable use by just unclipping the set and withdrawing it from the vehicle mount cradle.

This month I am describing one of these later sets, the 214.

Initial inspection

I received a phone call from a man who wanted his Ferris car radio/portable overhauled. It was mounted in an old Chrysler Valiant utility which he takes to vintage/veteran vehicle gatherings but, unfortunately, the set was not well. And so he brought it (and the Valiant) around so I could have a look at it before committing myself.

When he turned the set on, some rather strangled sounds came out of the speaker. Tuning across the band, I could hear a number of stations and so I thought that the set would be an economic proposition to repair (the owner didn't want to spend a mint). I then asked him to start the engine so I could check whether the vehicle interference was suppressed. Oh boy, the interference generated by the ignition system into the radio had to be heard to be believed! Well, that could wait.

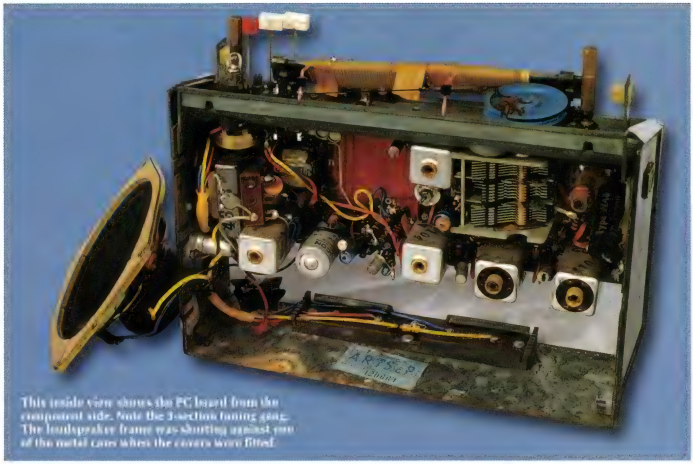
The more immediate problem was the horrible performance of the receiver. The set was removed from the vehicle and it really looked little the worse for wear – rather surprising considering its 30 years of portable and in-vehicle use. A couple of bars in the speaker grille had been broken but in other respects, the case's condition was quite fair.

These sets were built into a moulded metal case so that the works are shielded against ignition interference when they were used as a car radio. I told him that I might not be able to replace the missing bars in the speaker grille, which he accepted. He said the grille can't be seen when the set is in the vehicle cradle anyway. He was mainly interested that the set should work – not that it look a million dollars. Once marked, the metalwork on these sets is not easy to restore to pristine condition.

Despite its age, the old Ferris car radio was in remarkably good condition. For in-car use, the unit slid into a cradle mounted under the dashboard and was switched to use the vehicle's antenna.

Stripping down

First, it was time to strip the set down and see what was causing the



This inside view shows the PC board from the component side. Note the 3-section tuning gang. The loudspeaker frame was shorting against one of the metal cans when the covers were fitted.

horrible audio quality. Fortunately, the receiver came complete with a miniature circuit diagram pasted onto the inside of the cabinet. It was rather hard to read but I was able to get a larger copy from a fellow member of the local vintage radio club.

I looked rather carefully at the circuit to determine exactly what each section did and how it did it – particularly the facilities that allowed the change from portable to car radio use and vice-versa. At the aerial/antenna end of the set, the signal input is switched between the loop-stick antenna (when used as a portable) which is outside the metal case and the car radio coil which is inside the shielded case (quite nifty).

I then looked at how the switching was done to go from the 9V portable battery to the 12V car battery. The receiver itself is isolated from the metal case so it can be used with either positive or negative-earth vehicles.

A particular point of interest was how the operating conditions are changed in the set to allow it to work from 12V or 9V. It was quite simple really: the 9V battery was left in circuit at all times and the 12V vehicle supply "charged" it via resistor R33. This is a rather rough way of doing things as the 9V battery may be "charged" at up to 150mA when the vehicle battery is fully charged and the receiver volume is low.

However, at high volume, the battery supplies some current to the receiver, thus acting as a crude "voltage" regulator in this mode. It must have been rough on the 9V battery and I wonder how long it would have lasted with this sort of treatment.

The receiver circuit is quite straightforward for a set of this era (1960s). Australian manufacturers produced some excellent transistorised designs in the years before the Japanese forced them out of the market.

Australian sets of this era commonly had RF amplifiers and this Ferris design is no exception. The receiver has an RF stage, followed by a autodyne converter, two IF amplifying stages, a diode detector, two class-A audio amplifiers and finally a transformer-coupled class-B push-pull output stage. No fancy, tricky circuits here.

Many will remember that autodyne converter circuits were not too highly thought of in valve receivers and were replaced by triode hexode converters in the mid 1930s. However, the autodyne works well in transistorised equipment and is almost universally used to do the superhet conversion work in domestic broadcast receivers.

Fixing the audio distortion

Unfortunately, the set had been used as a car radio without the 9V dry battery fitted (this battery is no longer available). This concerned me as it meant that the set had been running on voltages as high as 14V instead of the intended 9V. In particular, germanium transistors such as the AC128s in the audio output section are not particularly tolerant of excessive voltages. Often, they will run for a short time on the higher voltages and then go into distortion, after which there is virtually no output.

This occurs because the transistors draw increased current as a result of the higher voltage and then they go into "thermal runaway" where the current keeps on increasing, in many cases until the transistors are de-

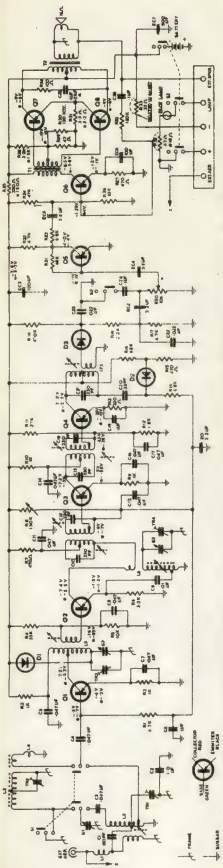


Fig.1: the circuit used eight germanium transistors and featured diode detection and a push-pull audio output stage.

stroyed. Some do return to normal once they've cooled down but failures are common.

I initially thought that one or both AC128 transistors had been damaged. However, before consigning them to the rubbish bin, I decided to do a number of checks. I connected the set to 9V from my small regulated power supply and found that the distortion noted earlier was still quite evident. I then checked the voltages around the AC128s and found them to be as per the circuit diagram.

Signal tracer checks

Remember, with PNP transistors everything is referenced to "+", which is "earth" or common. I suspected that the speaker may have been faulty and substituted my 9 x 6-inch test speaker but the quality was still terrible. I then thought that it was time to bring out the heavy artillery, so I fired up my signal tracer and checked each stage for audio quality and volume.

Initially, all went well – the volume increased as I moved from the base of Q5 to its collector, then onto Q6 and from there to the push-pull bases of the AC128s. However, when I transferred the probe to the AC128 collectors, the volume was down and the distortion was horrific. But despite the low output, the collector current through this stage was high (as shown by the voltage across R31).

So I now knew where the problem lay. I then found that slight pressure on the circuit board could cause the volume to increase dramatically, the quality to return and the collector current to reduce or vice versa. Ah ha, a cracked circuit board track – or so I thought.

And so, with the set operating, I checked the various voltages around the output stage but there was no indication of hairline cracks in any of the copper tracks. I also checked for short circuits all around the output stage of the receiver and could find nothing at fault. In the process, I replaced a couple of yellow ceramic capacitors with the red mark on them (Ducon "red caps"), as they have a reputation of not being all that reliable but that didn't help.

To add to my problems, parts accessibility in this stage is rather poor and it's difficult to inspect components, even with a headset magnifier and a mirror. In fact, once some components had been removed for inspection, their replacements had to be installed on the other side of the board due to the difficult access.

I was getting nowhere fast – just the slightest touch on the board could cause to behave or misbehave. In the end, I decided to replace C25. It is awkward to get at but that fixed the problem.

I checked the removed capacitor and it appeared OK. So what had caused a couple of hours of frustration? Perhaps the capacitor was faulty, despite the test, or perhaps there was sliver of metal causing an intermittent short in this area.

Anyway it works well now. Another serviceman/restorer had apparently given up on the set so the owner informed me.

Fortunately, the set didn't have major problems. However, if critical parts – such as the audio output transformer – had failed and were unavailable, I would have replaced the audio output stage altogether. SILICON CHIP's CHAMP amplifier which uses an LM386 audio amplifier is a good candidate for this job.

By the way, germanium transistors are now harder to obtain than valves. Silicon transistors can be used in place of germanium transistors in many cases but the base biasing has to be altered to suit.

Reducing the voltage

The next task was to reduce the rail voltage to the transistors to around 9V, regardless as to whether the set was connected to its own battery or to the vehicle battery.

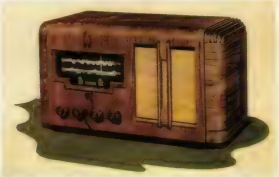
There are a few ways that this can be done but I settled for a simple method that closely mimics the set's operation when a battery is fitted. This simply involved fitting three 3V (0.5W) zener diodes in series across the battery plug, to regulate the voltage to a nominal 9V.

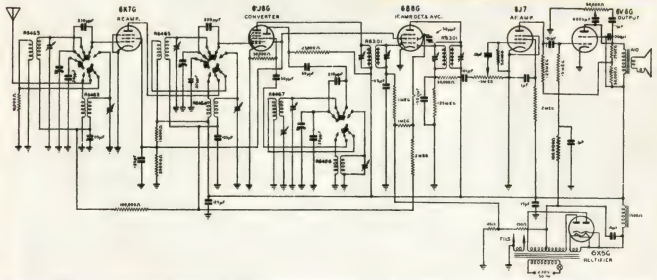
In addition, I added a 33Ω 0.5W resistor in series with R33 to reduce the current from the car battery. As a result, the voltage applied to the receiver does drop below 9V at high volume but this doesn't cause any problems with the performance.

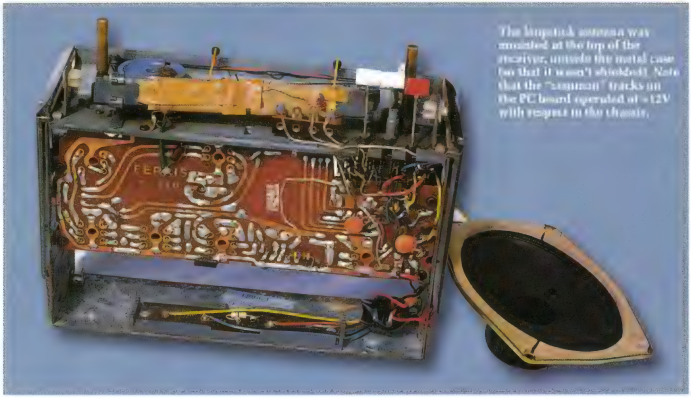
Close inspection of the circuit diagram reveals that the 214 was made in two versions: one for use with a 12V car battery (9V internal battery) and the other for use with a 6V car battery

Photo Gallery: Columbus Discovery Model 66

Manufactured by Radio Corporation of New Zealand during the 1940s, the Columbus Discovery Model 66 was a 6-valve 2-band receiver that came in both console and mantel models. They were fairly conventional superhet receivers with 455kHz IF stages and covered the broadcast band from 550-1600kHz and a shortwave band from 9.4-15.6MHz. The valve line-up was as follows: 6K7 (RF amplifier); 6J8 (converter); 6B8 (IF amplifier, detector & AGC); 6J7 (audio amplifier); 6V6 (audio output); and 6X5 (rectifier). (Photographs & diagram courtesy Ted Sherman, Kawhia, NZ).







(6V internal battery). This simply involved changing four resistor values.

A general check-over

I reconnected the set's speaker and found that it was causing distortion so I ratted my supply of speakers and found a 5 x 4-inch Plessey speaker that exactly matched the faulty one. I also decided that I should check the audio output to see whether the AC128s had been damaged but after listening to the receiver, it was apparent that they had survived their ordeal.

Next, I connected the RF signal generator, modulated by a 1kHz tone, to the receiver and connected an oscilloscope to the audio output. The 1kHz sinewave looked very good and even when the volume was increased to the point of distortion, I found that both transistors clipped symmetrically.

The alignment was also checked and it was found to be spot on in the IF amplifier and only required trimmer TR3 to be peaked at the high-frequency end of the dial. The set had retained its alignment well, despite the rough time it would have had over its life.

As mentioned earlier, the case was marked but it wasn't practical to repaint the painted sections. However, the chrome work came up quite well using automotive polish and a little elbow grease. The scratches are not obvious now.

Unfortunately, the old battery had been left in the set and the chemicals had leaked and eaten into the case. The battery type used in this set (2761) is no longer made but this is not really a problem. If the owner wants to use the set on batteries, a 6-cell AA battery holder (plus 6 x AA cells) and a battery snap connector would do the trick.

Like anything painted red that is exposed to sunlight, the dial pointers had changed from red to an off-white colour. For this reason, I keep a small tin of red enamel paint and, using a small artist's brush, I painted the pointers so that they now look like new.

In-car reception

The final test of the receiver was when it was mounted back in the Valiant utility. The reception was initially quite fair but when the engine was started up, the interference was horrendous. It looked as though I'd have to do some work on the vehicle's antenna system.

Suddenly, I remembered that we had been using the set on its own internal loopstick antenna. I switched the set to the external car radio antenna and the reception was now delightful, with virtually no interference – the antenna system was in good order.

When restoring and installing a car radio, it is necessary to check two things: interference from the car ignition system and the tuning of the antenna coil. Interference is usually cured (assuming that all the ignition suppressors are in place) by making sure that the base of the antenna is actually earthed (via the coaxial cable braid) to the vehicle. Cleaning rust from around this area usually cures the problem unless there is a break in the braid.

The antenna is very short so it is coupled very closely to the antenna coil. The antenna and the coaxial cable all act as part of the tuned circuit. With this all connected and the antenna fully extended, the receiver is tuned to around 1400kHz and the antenna coil trimmer is adjusted with a small screwdriver for best performance. The trimmer is accessed through a small hole alongside the tuning control.

In this case, the old Ferris receiver performed well right across the broadcast band so the trimmer (TR1) didn't have to be adjusted.

I returned the set to the owner but he rang me a day later and said that it was blowing fuses. He brought it back

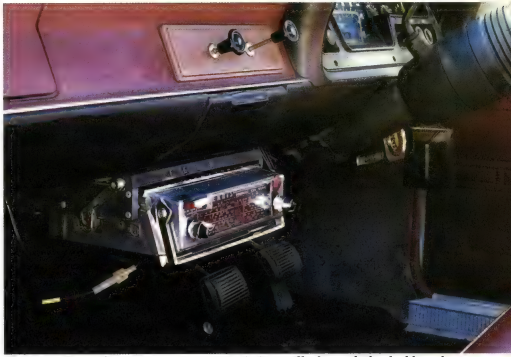
and testing revealed that a short existed between the +12V rail and the set's frame.

Dismantling the set revealed that the short disappeared when the back was removed. Some plastic electrical tape was put over the vulnerable sections of the PC board but the short reappeared when the back was replaced. I pulled the front and back covers off and the short disappeared again. At this stage, I suspected a short from the circuit board common (+) to the loudspeaker frame (-).

In this set, the speaker fits between the transistors, various other components and the coil cans. Using a dentist's mirror, I observed that one coil can did seem to be very close to the speaker frame. I put some tape over the can and that fixed the problem – success at last.

Summary

Ferris made some excellent radios and this is one of them. It is capable of being used as a portable or as a car radio with equally good performance. Its all-metal case ensures that it is well-shielded against car ignition interference.



This view shows the Ferris receiver sitting in its cradle, beneath the dashboard of the old Chrysler Valiant utility. They don't make 'em like this any more!

It's also is rather weighty for a transistor radio but is extremely robust.

This is a set well worth having in any collection and it is still a very practical receiver nearly 40 years after it was manufactured. Vintage radios certainly don't have to sit on a shelf gathering dust. **SC**

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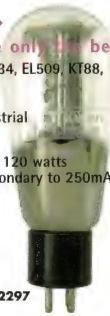

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Knock sensing for programmable ignition

I wanted to know if the Programmable Ignition kit from the June & July 1999 issues has provision to be used with a knock sensor to retard timing if detonation occurs? Does the kit in its current form allow the use of vacuum advance or is it purely just what you put in the program? What mods do you have to make to the engine or distributor to make this work? (P. S., via email).

● You might want to have a look at our Knock Indicator project from the April 1996 issue. However it does not act to retard ignition. Nor does the programmable ignition setup act on the vacuum advance.

Speed alarm cooks resistor

I recently decided to build the Speed Alarm (November & December 1999) as I had a close call with a speeding fine. I talked my friend into also buying a Jaycar kit and set about building the two of them. Turn on resulted in the 10Ω 1W resistor smoking away. I later found out that I had reversed the polarity of one of the two 47µF electrolytic capacitors.

Thinking this was the culprit, I replaced the electros, the 7805 regulator and the 10Ω resistor but the resistor still smokes. What have I missed, so I can finish my speed alarm and build the second one? I hope that the microprocessor is still OK as they sure are expensive to replace. (P. C., via email).

● Assuming that you did not reverse the polarity of the DC supply when you first connected your project, the most likely reason for the smoking 10Ω resistor is that ZD1, the 16V input protection zener diode, is reversed.

Speed control for LGB trains

With regards to the motor speed control project in the June 1997 issue, would it be feasible to use this as a variable speed control unit for LGB type model trains? Could the REF from pin 14 be used for the reference on a suitable DAC and the output of the DAC, with a suitable buffer, be used in place of VR1 which is 5kΩ pot? (R. M., via email).

● We would not recommend this circuit for model trains. We have published quite a few train controllers over the years. Have a look at the design featured in the October, November & December 1999 issues. Its output can be made compatible with the higher voltage needed by LGB models by substituting a transformer with a higher secondary voltage.

Speed control for a golf buggy

I have taken over an electric golf buggy business and need help in designing a new speed controller. The one used at the moment is unreliable. The buggy is run by a 12V 180W DC motor and the electronics has two MJ802 transistors which are prone to blowing under load. The motor can pull up to 45A. What sort of circuit would your suggest? (J. E., via email).

● Mosfets are the answer. Have a look at the 50A speed control published in the May 2000 issue.

Voltage checks when building the Theremin

I am constructing the Theremin which appeared in the August 2000 issue of SILICON CHIP. I have only a basic knowledge of electronics, so I have a few questions.

Firstly, both the DC socket and the S1 power switch have three connectors and in the component overlay in Fig.5 of your article only two connectors are featured on both of these for wiring. I am not sure which connectors on these components I should be using or does it even matter?

Secondly, when setting up or tuning the Theremin you describe checking voltages at various points. For instance, "there is a nominal +6V between the case of one of the transformer coils and pin 8 of IC2 & pin 6 of IC3. The voltage should be between +5.6V and +5.8V." Plus, there are other references to checking voltages at the cathode of diode D1 when aligning the volume plate, etc.

As I am a newbie, can you tell me

How to eliminate the distributor

I wish to convert my car ignition system to distributor-less operation, ideally using one or two Hall Effect sensors to trigger the electronics to fire the coils or ignition systems. I'm not sure how to achieve the electronics part to count the pulses from the Hall triggers to fire the correct coil/cylinder.

Naturally, there are quite a few aftermarket manufacturers who produce such complete packages but they are quite expensive. Can you help? (P. W., via email).

● Have a look at the High Energy Ignition circuit in the July 1998 issue. It can be triggered by Hall Effect pickups and contains the necessary interface circuitry. If you are going to use one coil per cylinder you will need one Hall Effect pickup per cylinder. If you only want one Hall Effect device, operating from a toothed vane on the harmonic balancer (say), then you will need counter circuitry and some method of identifying the firing point for cylinder one, for correct timing.

You also need to allow for ignition advance. Without going to a full engine management system, you are really facing complications. Our preferred method would be to convert the distributor to Hall Effect or reluctor pickup.

exactly how I go about doing this? I have a multimeter but am never exactly sure where to put the probes to check all of these things.

In fact, a beginner's article on exactly how to use a multimeter to check your work and find faults in a circuit would be greatly appreciated in your magazine. (Z. C., via email).

● The switch should be wired so that its two terminals are closed when set to the ON position. You can check this by selecting "ohms" on your multimeter then using the two terminals that show a short circuit (zero ohms) when the switch is on. Make sure that the terminals become an open circuit (high resistance) when the switch is set to off.

The best way to check the DC socket is to plug in the plugpack and measure the voltage on the socket terminals. Do this before soldering the DC socket to anything. The positive terminal is the one which shows positive voltages on the multimeter when the red multimeter lead is connected to it. The black multimeter lead connects to the negative terminal on the socket.

Measuring voltages on the Theremin circuit is done similarly. Connect the black multimeter probe to the case of a transformer, then measure voltages with the red probe. They should be similar to those quoted in the article.

If you are having trouble with measuring voltages on the circuit, you could just try the Theremin without voltage checks and adjust the cores of the transformers as described while skipping the voltage measurements.

Turbo timer countdown problem

I purchased a Turbo Timer kit as described in the November 1998 issue of SILICON CHIP and upon testing it I discovered that when the ignition switch is left on the timer is activated and starts counting down, so when the ignition is ultimately switched off there is no countdown. What should I do? (G. B., via email).

● Try increasing the capacitor value at pin 4 of IC1. This 100µF capacitor holds the timer reset until after a set time determined by the 10kΩ resistor connecting to the 12V. A value of 470µF should be enough to extend the reset time so the circuit will not trigger with power on.

Temperature compensation for pH meter

I am writing to inquire if it would be possible to modify the pH meter for swimming pools (published in April 1988) so that temperature could be compensated for automatically. I was thinking of putting an LM355Z in series with the 6.8kΩ resistor (insulated and on a length of wire so it can be placed in the solution) but I'm not sure of the correct way to do this.

I want to feed the output voltage to an ADC so I can automate the pH control system and log the data on a PC. The temperature will vary from day to night and this is why I want to compensate the temperature automatically. Do you have any suggestions? (J. E., via email).

● The temperature compensation in the pH meter changes the slope characteristic from the sensor. In other words, just adding or subtracting an external voltage will not alter the slope. This would require some sort of variable resistance which changed with temperature instead. You may be able to use a thermistor which is altered with parallel resistance to set the resistance change with temperature.

Alternatively, the measurement can be altered in your computer to follow the graph in Fig.1 of the pH meter article. A separate temperature input for the computer would be required.

Apart from this, the pH probe does not change much in output over the normal range of temperatures expected to be found, especially in Australia where temperatures are reasonably stable over a season. Maybe your automation can tolerate ignoring any temperature changes?

Minimitter tuning is odd

I've had a strange problem with the FM Stereo Minimitter described in the April 2001 issue. Adjusting L1 works fine but L2 seems to have no effect. The radio receiver I'm using indicates FM stereo regardless of the tuning of L2. Could you please advise me on this? (B. M., via email).

● We suspect that coil L2 is not connected electrically to the PC board. Check that there is continuity through the coil by measuring its resistance between the relevant tracks on the PC board (using a multimeter). The most likely cause is that the enamel insulation has not been cleaned off the wire ends.

Alternatively, the capacitor across L2 may not be soldered correctly or it is the wrong value. It should be 47pF. Or maybe the 3-10pF trimmer is shorted or L2 is wound or terminated incorrectly.

Tachometer with shift indicator

Jaycar has suggested that I contact you with my need for an automotive tachometer with a bargraph display. I am not interested in knowing the actual value of the engine rpm, just an indication when approaching the upper and lower limits of engine speed and guidance in selecting the best speed for gear changing. The bargraph display, if mounted remote from the rest of the electronics, could be quite small and unobtrusive, yet very effective if mounted, say, with double-sided tape centrally just outside the glass of the instrument panel. (J. B., via email).

● Have a look at the Rev Limit Controller that we published in the April 1999 issue. While specifically intended as a rev limiter project, it can also be used as a Shift Light. We can supply the April 1999 issue for $7.70 including postage.

Optical pickup for Rev Limiter

My car is a 1993 Nissan Silvia which uses a LED system inside the distributor. I was just wondering if there is a different pickup circuit for the Rev Limiter described in the April 1999 issue. If not, which of the two systems would work, reluctor or the Hall Effect system? (G. H., via email).

● We published details of how to use an optical pickup in the Ask Silicon Chip pages of the August 1998 issue and the Circuit Notebook section in the October 2000 issue, page 58. The August 1998 version should suit.

Optocoupler breaks down in welder

If possible, could you please help me with the following problem? We have an inverter welder that has been imported from Europe. The machine has an input rating of 230VAC and the manufacturer has stated that running the welder at 240VAC would pose no problem.

The problem is that a MOC3023 optocoupler is breaking down and letting AC flow back through the circuit and cause the solenoid to chatter. The optocoupler drives a gas solenoid rated at 230VAC 13.5VA and incorporates an RC circuit which consists of a .022µF capacitor and a 22Ω watt resistor connected in parallel.

My question is, would the 10V increase in the primary generate a sufficient increase in the breakdown voltage to cross the protection threshold and blow the optocoupler? And is there any formula to work out what the break-down voltage would be? (P. D., via email).

- The MOC3023 only has a 400V blocking rating so depending on what it is driving, it could easily be fragile, especially in a welder. Given that its load is only a low current, the designers probably thought that it would easily handle the job.

Our approach would be to use the MOC3023 to drive a 600V Triac but one with a low holding current or alternatively, shunt the solenoid with an incandescent lamp to ensure reliable operation. You may also need Varistor protection in the circuit.

Question on modifying PC power supply

With respect to the article entitled "Use your old PC power supply for high current outputs" in December 1998, how high is the "high current". Also, have you ever described the theory behind high power Mosfet auto amplifiers?

Can the output current of the Power Supply for Amateur Transceivers described in May/June 1991 be increased to around 30A relatively easily? (T. C., via email).

- The December 1998 article dealt with modifying a standard PC power supply to deliver slightly higher voltage; eg, 13.8V instead of 12V. Typically, you can get 8A from the 12V rail and 20A from the 5V rail.

We have not published any theory behind Mosfet car amplifiers. They are just standard Mosfet amplifiers powered by a DC-DC inverter. The output of the 13.5V 25A supply cannot be increased without substantially upgrading the major components.

How to connect a subwoofer amplifier

I'd be the first to admit that I am a novice in the field of electronics. With perseverance and a lot of reading I had thought that I had developed a basic understanding of audio amplifiers, until now.

I have built a couple of amplifier modules supplied by Dick Smith Electronics, namely the 100W module (Cat. K3442) and the more powerful 300W beast, primarily to power subwoofers for my home-theatre system. Each amplifier module has the Sub Bass Processor preamp module (DSE Cat. K5403). My dilemma is this: if I use the subwoofer out jack on my surround receiver I get virtually no signal through either amp module. If I connect the same subwoofer output to my small 30W bookshelf stereo and get this to power my subs, I get thumping bass but only 30 watts worth.

Obviously there is signal coming out of the sub out jack, so why is it lost between here and my speakers? (S. F., via email).

- The sub-bass processor should not be connected to the subwoofer output of your surround sound receiver. The sub-bass processor is intended for those people who do not have a subwoofer output from their receiver. Try connecting the subwoofer signal directly to your 100W amplifier. You should get heaps of bass.

Bridging audio amplifier modules

I've bought two power amplifiers from Dick Smith Electronics (Cat K3442) and I would like to bridge them. What do I need and can it be done? (E. P., Vermont, Vic).

- There is a problem in bridging these amplifier modules. As they stand, they will deliver 100W into 4Ω or 50W into 8Ω. If they are bridged, they will only deliver 100W into an 8-ohm load. They cannot drive a 4-ohm load in bridge mode, since each module cannot drive a 2-ohm impedance.

Notes & Errata

Touch/Infrared Light Dimmer, January & February 2002: the circuit diagram (Fig.3) should show the .01µF capacitor and 1MΩ resistor connected to pin 6 (RB0 input) of IC1 and not to the A2 terminal of TRIAC1. The PC board pattern and overlay diagram are correct. **SC**

WARNING!

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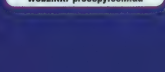

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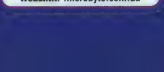

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New in original box with instructions. This unit was designed to charge NI-CD & NI-MH mobile phone batteries of 4.8V, 6.0V and 7.2V. Operates from 12-24V DC input. Features include processor control & multi stage charge indicator. By changing the value of one resistor it can charge higher voltages, although a higher voltage plugpack is required for 9.4V or higher. Includes cigarette lighter lead, 12V / 1A DC plugpack & instructions for modifications for higher voltages. The unit has battery charging terminals but the user will have to make their own adaptor to interface to a battery. The plugpack supplied alone is worth around $30 retail. Weight is 0.9kg. This charger requires a small voltage across the battery before it will start charging - therefore it won't be able to start charging a completely flat battery. (ZA0100) $29

(NEW) SONIC BRAND HEAD CLEANING FLUID & TAPE:
This cleaning kit contains Non-abrasive head cleaning tape but most importantly it contains an equi free cleaning fluid (15ml) (most likely ISOPROPYL ALCOHOL) 4 for $2

PANASONIC
EX-OLYMPIC
$295
With camera

PANASONIC MONITOR / TV
Slightly Used TC-14S15A 34cm Colour / Audio /Video MULTI STD. Monitor system with an added bonus of built in Television & with full function remote control in original boxes. As used buy the worlds athletes during the Olympics. The Easicon Menu features colourful icons for greater ease when making settings & adjustments. Choose among English, Chinese, Russian or Arabic for the on-screen prompts. RRP: $419. Features inc. A/V in & out to cascade to other monitors etc. 34cm High Contrast Tinted Picture Tube Picture Improvement Circuitry Channel Colour Set : High, Std. & Low, Picture Menu : Dynamic, Std, Soft, Two Colour Temp. : High, Low Easicon Menu, Child Lock, 2 AV Input (F-R) / 1 AV Output, Weighs 9.6kg, 358 W, 389 D, WEIGHT 9.6 Kg, BUT WAIT... THERE IS MORE... You also get a colour CMOS camera with audio & a suitable plug pack. ALL FOR JUST $295. All you have to do is fit common RCA connectors to the camera cables.

USED) LOW COST PRINTER:
These serial interface printers are in good condition & were made in England. With ribbon installed. A rugged printer & is useful for Point of Sale applications. It is able to be used on a wide variety of hardware not confined to a PC. Most equipment with a std RS232 port is capable of using this printer.

(ZB0340) $50 each (limited quantity)

2.4Ghz 4 CHANNEL VIDEO AND STEREO AUDIO TRANSMITTER AND RECEIVER KITS & ANTENNA PLANS.
These simple and easy to build kits are ideal or experimentation for radio LAN or amateur TV. Requires 12VDC. MINI 2.4GHz VIDEO TRANSMITTER MODULE:
15 x 15 x 5mm. This is the smallest 2.4 GHz transmitter we have seen. Requires 5Vdc and will transmit up to 100M with a 30mm wire antenna. Mini module + Pre-built receiver (K171C +K171A) $169

STEREO AUDIO VIDEO TRANSMITTER / RECEIVER KIT:
This kit contains K171C & K171D modules & inc. PCBs & all on-board parts. These PCB's house voltage regulators & RCA connectors on the receiver only: (K171B) $119

2.4GHz STEREO AUDIO VIDEO TRANSMITTER MODULE: Will transmit up to 100 metres with a 30mm wire antenna. Std. TX module + (K171C) RX module: (K171D) $99

2.4 GHz VIDEO TRANSMITTER ANTENNA PLANS : Check our website for downloadable plans to build a antenna made from a "PRINGLES" chip container to suit this kit. We tested one of these antennas fitted to the receiver only, over a distance 500M we received great audio and video signal.

(NEW) DECOR COOLER BAGS:
Brand new high quality large Decor brand 28 litre cooler bags in their original sealed plastic bags, leak proof, triple layer insulation, durable outer fabric, wipe clean water proof inner liner, available in blue or red, easily fold into a flat compact shape these retail for around $40: (ZC0120) $16 each

(NEW) INDUSTRIAL COUNTER: HENGSTLER \model# 0711100. Industrial counter with a 6 digit LED display, 2A SPDT relay contact output, needs a 12 V DC power supply and a closed mechanical contact or a saturated transistor to clock (Active "low"). Battery included but may need changing: (ZC0116) $33 each

(NEW) ZERO-CROSSING SOLID STATE RELAY (SC842910):
Maximum switching current is 25A, Maximum Swithcing voltage is 12-280V AC and Control Voltage 90-240V AC. (RL7A) $25

(NEW) Zero-Crossing Solid State Relay (SC844910): Maximum switching current is 40A, Maximum Swithcing voltage is 12-280V AC and Control Voltage 90-240V AC. (RL7B) $33

(NEW) Zero-Crossing Solid State Relay (SC868110): Maximum switching current is 95A, Maximum Swithcing voltage is 24-520V AC and Control Voltage 5-30V DC. (RL7C) $89

(NEW) Zero-Crossing Solid State Relay (SC869110): Maximum switching current is 125A, Maximum Swithcing voltage is 24-520V AC and Control Voltage 5-30V DC. Check the following website for more information: http://www.celduc-relais.com/uk/biphase.asp? (RL7D) $100

(NEW) ALCATEL ESWA HEATING CABLE:
Type TXXP 500V - 0.70 OHM/M - (2893). part No.(099956) or (0.20 ohm/m) part N0. (099957) This extremely strong high quality cable is designed to be embedded into concrete. Can be used for many applications, but is especially attractive to those who wish to lay into their concrete (when building) so that they can have localised heating. Constructed of three 1 mm wires at the centre and then wrapped with 4mm (diameter) of black silicon, with a plastic sheath. Total width is ~5 mm. Minimum purchase of 10 metres. $7 for 10M

POWER TRANSISTORS 2N3055...
New TO3 package metal cased power transistors, large but limited stock: $1.20Ea. or 10 for $8

NEW KITSNEW KITS**
SOUND CARD INTERFACE:
AS featured in this magazine.
Turn your PC into an oscilloscope with this kit. We will supply the complete kit including project case, knobs, label, PCB-all onboard components Plug Pack and connectors. Software is free to do download from the net. Available late August. Send E-mail Please, don't ring

DIGITAL STORAGE LOGIC PROBE
AS featured in this magazine.
Turn your PC into a digital storage probe with this kit. We will supply the complete kit including project case, knobs, label, PCB, all onboard components Plug Pack & connectors. Software is free to do download from the net. Available late August. Send E-mail Please don't ring

STEPPER MOTOR DRIVER KIT:
This kit is designed to drive 5 or 6 wire stepper motors and is based on three common ICs & four Mosfets (IRFZ44). This controller operates in either free-standing mode or PC controlled. Operates from 8 to 35V DC. PCB measures 72 x 42mm. Kit includes PCB and all on-board components. The software is not supplied but can be downloaded from http://www.metalworking.com or http://www.kellyware.com No case is supplied. Published in Silicon Chip Magazine (May 2002) (K179) $24
Mini stepper motor: (MS55) $7 each. Package (Kit plus stepper motor): (K179M) $29

** BARGAIN **

(NEW) COLOUR CHRISTMAS LIGHTS (80LIGHTS) Plug-pack not supplied, In original packaging (may be shop soiled) $8

REMOTE CONTROL TRANSMITTERS
Brand new Radio Shack two channel crystal controlled

27MHz transmitters with 2 3 position joystick, need 9V battery, style can differ from the pictured unit: $7 Ea. Or 2 for $10

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